GCSE ICT
Theory Pack 1

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1 Data and information

Information and data

Data is what is input to a computer system. On its own data has no meaning. To have meaning, data must have a context. Consider the item of data in the table. It could have three different contexts.

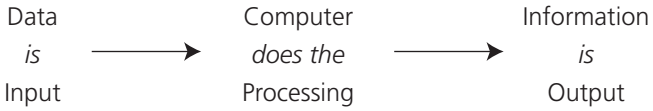
Data	Possible context
040389	Area telephone code
	Map grid reference
	Date of birth

Once the data has been given a context then it has meaning. It becomes information:

Data + Context = Information

Another way of looking at data is to say that it is the raw values that are put into and stored by a computer system. The computer system will process the data to provide information to the people who use it.

A company selling various products may feed data about each sale into a computer. This data could be processed to provide information about which items were the bestsellers or how much money was taken at different times of the day. Managers can use information provided by the computer to help them plan and make decisions. Hence:



Why use computers?

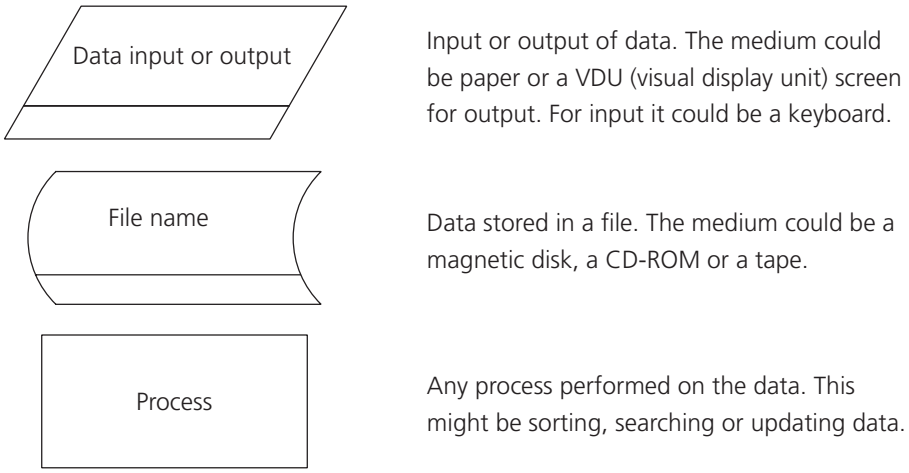
Computers are data-processing tools. There are many reasons why computers have become so widely used but the main reason is that they are very good at doing the sorts of data-processing tasks that are essential in a modern world.

Type of task	Example	Reason for using a computer
Volume – There is a lot of data to be processed.	Processing all the cheques that are written each day.	It would take too many people to process the data.
Repetitive – The processing is repetitive; the same things being done to lots of similar data.	Calculating electricity bills for a large number of customers.	Humans would become bored and make mistakes.
Speed – Processing has to be done quickly.	Controlling the launch of a space shuttle.	Humans could not process the data quickly enough.
Accuracy – The processing must be accurate.	Calculating all the pay packets for the employees of a large company.	Humans would make mistakes in the calculations.

Data stored in a computer system will take up less room than the same data stored in a filing cabinet. It is also more accessible since data stored centrally can be viewed by any number of people at the same time, each using their own terminal linked to a central data source. In addition, it is easier to find the data when needed because the computer system can search through all the data stored to find the particular item that a user needs.

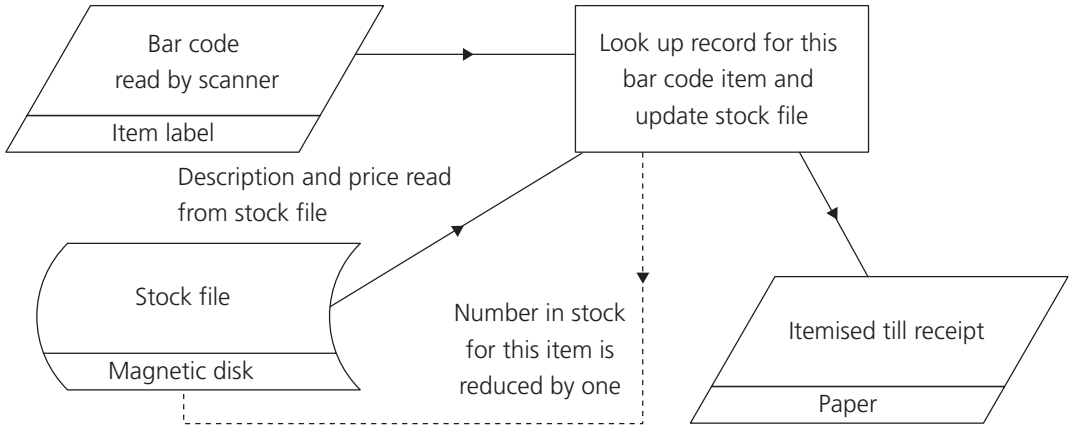
System flow charts

When we study computer systems, we look at the way that data is collected, input, processed, stored and finally output as information. System flow charts are used to show what happens to data as it passes through a computer system. Different symbols are used to represent the different things that can happen to data in a computer system.



System flow chart symbols

The symbols are linked together by lines that show how data moves through the system. When you draw a flow chart, remember that its purpose is to help explain the movement of data through a computer system. You should write any additional information on the flow chart or beside the boxes if it helps to describe the way that data moves through the system that the flow chart is describing. The following flow chart describes the movement of data when an item is sold in a supermarket:



Flow chart of supermarket system

Key points

- Data is input to a computer system and stored by it.
- Information is processed data – it is output from a computer system.
- A system flow chart is a diagram that shows the flow of data through a system.

Questions

1 When an item is sold at a supermarket, the bar code number is fed into the supermarket computer as data. Name two items of information that you would expect the computer to be able to produce by processing this data.

2 If a computer stored the surname, first name, sex and date of birth for each of the students in your ICT class, give three items of information that your ICT teacher would be able to get by processing the data.

3 Why is it easier to get information from the data stored in a computer system than from a paper-based data system?

4 Give two other advantages of using a computer to store and process data.

2 Input devices

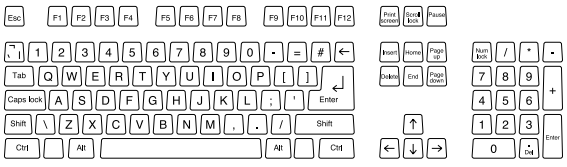
Any device that is used to enter data into a computer system is called an input device. There are many different types of input device, each designed to provide an efficient method of data entry in particular circumstances. You should be able to work out from the strengths and weaknesses of each type of input device the sorts of jobs it would be suitable for. When choosing an input device, the following factors should be considered:

- the type of data to be input
- how quickly the data needs to be input
- the volume of data to be input
- how easily the person inputting the data will be able to use the device
- the amount of desk space the device will use (its 'footprint').

Keyboard

The keyboard is the most commonly used type of input device. It is often called a QWERTY keyboard after the arrangement of the letters on the top row. This arrangement of letters was first designed for use on mechanical typewriters and its purpose was to reduce the number of key jams when the typist was working quickly. Training is needed to use the keyboard effectively.

Modern computer keyboards also include special function keys, which can be used by software to provide fast access to functions or menus. In addition, many application packages will recognise 'hot key' combinations. One example of this is turning bold on in a word processor package by pressing the CTRL and B keys together.



QWERTY keyboard

The various attempts to introduce new keyboard layouts to allow faster text entry have failed. This is because of the amount of training invested by people who have learned to use the existing layout. Recently, the overall shape of the keyboard has been designed as a curve. This reduces the amount of movement necessary to hit a particular key and so speeds up data entry.

Specialised keyboards have been developed for particular applications. For example, many fast-food chains use a keyboard that shows pictures of various meals on the till. This speeds up data entry and makes it easier to train staff. Keyboards with keys that have pictures to represent ideas or sales items are called concept keyboards. This type of keyboard is also used in primary schools with computer-aided learning systems.

Some of the advantages and disadvantages of keyboards are as follows:

✓ Good for manual text entry.

✓ Special keys can be used for special functions.

✓ Hot key combinations can simplify tasks for expert users.

✓ Familiar device – even for novice users.

✓ Specialised keyboards can be used to speed up data entry.

✗ Mistakes easily made – even by trained users.

✗ Large footprint – takes up a lot of space on a desk.

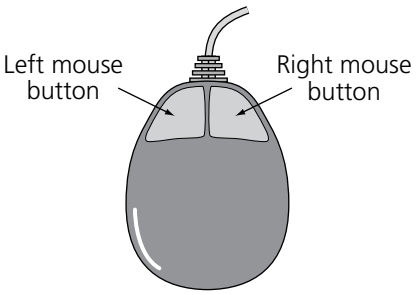
✗ Data input is slow compared to many other devices.

✗ Of limited use for moving, selecting and drawing.

✗ Specialised keyboards can only be used for a limited number of data values.

Mouse

A mouse is often used together with a keyboard. This is because the mouse is very good at inputting the sort of data that the keyboard does not handle well. The need for a mouse, or similar device, developed with the introduction of graphical user interfaces, like Windows, where the user needs to point to and select items shown on the computer screen.



As the mouse moves, it transmits data to the computer about the speed and direction in which it is travelling. The computer usually represents this data by the position of a pointer on the screen. As the mouse moves, so the pointer on the screen also moves. The user can select items on the screen by clicking a button on the mouse. This combination of data (movement plus selection) makes the mouse useful for selecting items from drop-down menus or performing operations on files represented as icons on the computer screen.

Optical mice have no moving parts and so do not suffer from dirt clogging the mechanism that detects the mouse's movement. Wheel mice have a wheel in the centre that allows the user to scroll through documents.

A special type of mouse that can be used in mid-air rather than needing a flat surface has been developed for use with presentation software, when the person using the mouse may be moving around the room. This is called a gyro mouse because it detects movement using a gyroscope.

Some of the advantages and disadvantages of mice are as follows:

✓ Good for inputting movement and speed (converted to position).

✓ Good for selecting items in a graphic interface or from menus.

✓ Small.

✗ Not very good at inputting text.

✗ Need a flat space to operate on (except gyro mouse).

✗ Behaves badly in a dusty or dirty environment.

Touch pad

A touch pad does much the same job as a mouse but in a completely different way. The touch pad is a flat area. When the user places a finger on the surface of the touch pad, the pad detects its position. Movement of the finger is tracked and the computer system moves the pointer on the screen accordingly – just as with a mouse.

Tapping the touch pad is equivalent to left-clicking the mouse, although two buttons are normally provided below the touch pad to reproduce the left and right buttons on a standard mouse.

Touch pads can be customised so that certain areas on the surface perform specialised functions. An example of this would be to set the right-hand edge of the touch pad to perform the same scrolling function as the wheel on a wheel mouse. Documents could then be scrolled through by moving the finger along this specially configured edge.

This type of input device is commonly used on laptops, since these computers are often used where there is no suitable flat surface on which to place a mouse.

Some of the advantages and disadvantages of touch pads are as follows:

- ✓ Good for inputting movement and speed (converted to position).
- ✓ Good for selecting items in a graphical interface or from menus.
- ✓ Can be built into the laptop and positioned close to keyboard for ease of use.
- ✓ Can be customised using software provided.
- ✗ Not very good at inputting text.
- ✗ Limited range of functions – maximum of three buttons.
- ✗ Some users find it difficult to operate.
- ✗ Actions can be accidentally triggered by hand or fingers unintentionally resting on the touch pad.

Trackerball

A trackerball is yet another pointing device. It is like an upside-down mouse with the ball uppermost. The user turns the ball directly rather than by moving the device over a surface, as is the case for a mouse. Therefore, the trackerball does not need a surface to move over.

Small trackerball devices are used in some laptop computers but they have not become as popular as the alternative touch pad.

Larger trackerballs allow precise positioning of a pointer on a screen and are sometimes used in design applications where accurate input of position is a more important input than speed of movement.

Some of the advantages and disadvantages of trackerballs are as follows:

✓ Good for inputting changes in position accurately.

✓ Do not need a flat surface to operate on.

✗ Not very good at inputting text and can be awkward to use as a general purpose pointing device.

✗ Unresponsive to speed of change (eg unsuitable for spray painting).

Joystick

A joystick, which takes its name from the control device used in aircraft, is used to input movement and direction. Buttons on the stick provide additional input. This type of device is used extensively for input in games programs where moving the stick is translated into movement in the game.

Joysticks are also used as input devices for flight simulators in some virtual reality applications. Over the years, joysticks have evolved to become highly-specialised input devices particularly for gaming applications.

Some of the advantages and disadvantages of joysticks are as follows:

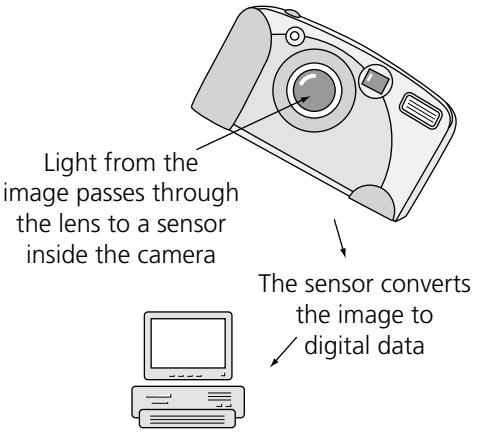
✓ Good for inputting direction.

✓ Mimics the behaviour of a real joystick.

✗ Limited to one type of input.

Digital camera

A wide range of digital cameras is available. At the cheaper end of the market, many digital cameras allow still photographs to be taken and also very short sequences of video. This type of camera can also be connected directly to a computer to provide a Web cam allowing low resolution and rather jerky pictures to be transmitted over the Internet to another user. This provides a very basic form of video conferencing.



More expensive digital cameras specialise in providing high-resolution still images. This type of camera reproduces many of the features seen on standard cameras. Pictures are generally stored in the camera's memory and can be downloaded to a computer disk and the camera's memory can then be cleared ready to store more pictures. The user may be able to select the resolution. Higher-resolution pictures store more detail but also take up more storage space.

Many cameras now come with the facility to print pictures directly. Home users would probably use a colour ink-jet printer to print pictures and the quality of the final printout can be enhanced by using special glossy ink-jet paper.

Digital video cameras are also becoming popular. These store digital moving images onto digital tape or disk.

Some of the advantages and disadvantages of digital cameras are as follows:

✓ Pictures captured in a format that can be read directly into a computer with no need for scanning.

✓ Lower running costs than traditional camera – particularly if there is no need to print the picture.

✓ Images can be easily edited.

✗ Images can take up a lot of storage space if stored on a hard drive.

✗ Unlike a scanner, cannot handle text well (OCR – optical character recognition).

✗ May run out of memory space or battery power while being used.

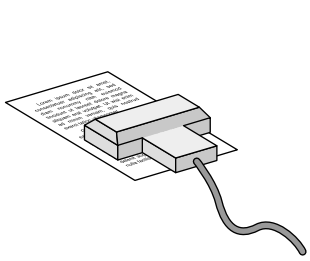
Scanner

A scanner is used to input pictures or text. If a picture is being input, the scanner will convert it to an image made up of a large number of dots. The number of dots per inch is a measure of the scanner's resolution. More dots per inch means a higher resolution or better quality images. However, it also means that the size of the picture file will be larger. Hence, the image takes up more space on the disk and takes longer to process.

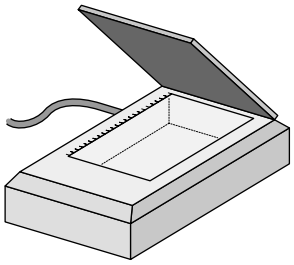
A scanner can also be used to input text from a document using Optical Character Recognition (OCR). In this case, the image produced by the scanner is used by OCR software to recognise each character on the page. The characters are then stored in the same way as other text input. The scanned document can then be used like any other text document.

There are two types of scanner – hand-held and flat-bed scanners. Hand-held scanners are small devices that are moved by hand across the document being scanned. They are small and cheap but there are problems when scanning larger images since several scans will be needed to cover the whole page. The individual scans then have to be 'stitched together' by software.

With a flat-bed scanner, the page being scanned is placed face down on the glass of the scanner where it remains while the scanning device moves under it. This tends to produce a better quality scan than a hand-held scanner but the device does take up more room.



Hand-held scanner



Flat-bed scanner

Some of the advantages and disadvantages of scanners are as follows:

✓ Good for inputting pictures and line art.

✓ Good for inputting large amounts of text using OCR.

✗ Files can be large, particularly if high resolution colour is used.

✗ Text can be incorrect. Some characters like zero and the letter O can be confused.

✗ Flatbed scanner has a large footprint.

Microphone

Microphones are used for inputting sound to the computer. The sound may be stored in one of two ways. One way is to make a digital recording of the sound which can be played back at a later stage, perhaps as part of a presentation package or as a recorded message.

Alternatively, the sound data can be used as part of a voice recognition system. Words are input in much the same way as a letter or notes might be dictated. The computer system interprets the sound input, recognises the words and stores the data as text. This is a developing method of inputting documents and has an advantage over the keyboard in that little or no skill is required. Voice recognition systems are also very useful for handicapped people who are unable to use the keyboard, or in situations where the user needs both hands free.

Some of the advantages and disadvantages of microphones are as follows:

✓ Any sound can be input and stored.

✓ Reasonably fast text input without the need to learn keyboard skills.

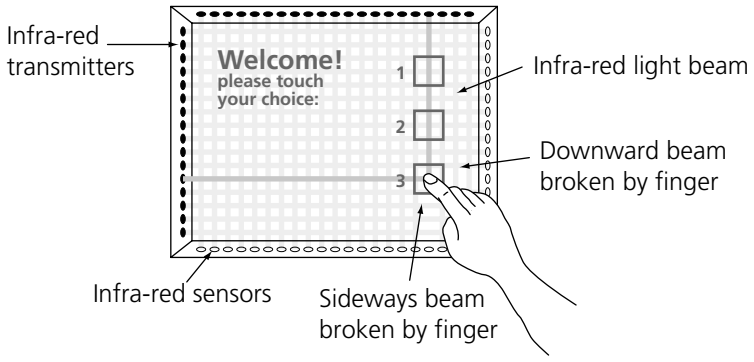
✗ Needs a quiet environment.

✗ Software needs to learn to recognise speech patterns for text input.

✗ Limited to one or two users.

A typical application is in inputting numbers and commands in a 'hands free' car phone.

Touch-sensitive screen



For this method of input, the computer detects where the user's finger is touching the computer screen. This is particularly suited to selecting an item from a list by pointing to it on the screen. Touch-sensitive screens are sometimes used in shops as part of a computer-controlled video display. The use of a touch screen means that there is no need for a keyboard or mouse that might easily be damaged or stolen. It is also used with small children in teaching programs.

Some of the advantages and disadvantages of touch screens are as follows:

✓ No moving parts to get damaged or dirty.

✓ No special skills needed to use it.

✗ Special monitor needed and this is expensive.

✗ Input restricted to selecting from a small number of options.

Light pen

A light pen looks like an ordinary pen apart from the fact that it has a cable connecting it to the computer. Although it looks as though the pen draws on the computer screen this is not, in fact, what is happening. An electron beam, controlled by the computer, builds up the picture on the screen. The light pen detects when this beam passes and sends a signal to the computer. The computer measures the time between the beam beginning its scan at the top of the screen and it reaching the pen. From this data the computer can calculate the position of the pen on the screen.

The light pen is therefore essentially inputting data that tells the computer where on the screen it has been placed. This input can be used as part of a drawing program with the pen being used to select tools and to mark points on the drawing.

Some of the advantages and disadvantages of light pens are as follows:

✓ Good for inputting drawing data, eg start and end of a line.

✓ Small footprint.

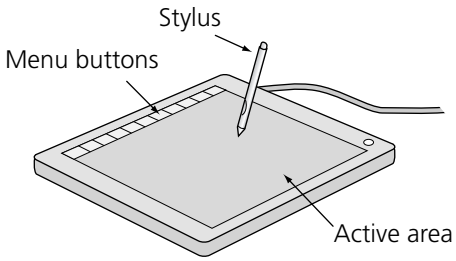
✓ Similar to a pen or pencil that the user will be familiar with.

✗ Poor at inputting more general data such as text.

✗ Not widely available.

✗ Accuracy is low.

Graphics digitiser



This input device, which is also known as a graphics tablet, consists of a flat surface together with a pen-like device called a stylus. The position of the stylus on the tablet is converted to data that is sent to the computer. This combination allows accurate drawing data to be input. The graphics digitiser acts rather like a drawing board and pen as far as the user is concerned. A typical application would be for inputting architectural plans.

Some of the advantages and disadvantages of graphics digitisers are as follows:

✓ Good for inputting drawing data, eg start and end of a line.

✓ More accurate than a light pen.

✓ Familiar look and feel for the end user.

✗ Poor at inputting more general data such as text.

✗ Graphics tablet takes up room on a desk (large footprint).

Key points

- Input devices are used to enter data into a computer system.
- Different input devices have different strengths and weaknesses that make them suitable for inputting different types of data or for use in different situations.
- The choice of which input device to use will depend on the type of data to be input and the situation that it is to be used in.
- Some of the input devices available are: keyboard, mouse, touch pad, trackerball, joystick, scanner, digital camera, microphone, touch-sensitive screen, light pen and graphics digitiser.

Questions

For each of the activities listed below, give one or more suitable input devices and say which features of the device make it particularly suited for use in this application.

a Inputting names and other details of guests staying at a small hotel.

b Inputting a complicated design or architectural drawing.

c Inputting a copy of a photograph to use in a brochure.

d Selecting a paragraph of text to put in italics in a word-processing program in use on a desktop computer.

e Selecting a choice of what to see next in a computer-controlled video display that demonstrates items on sale to customers.

f Inputting which of several possible answers is correct in a teaching program for young children.

g Inputting several thousand names and addresses that are currently available in a printed version.

h Capturing a picture of a school for use on the school Web page.

i Selecting a paragraph of text to put in italics in a word-processing program in use on a laptop computer.

3 Output devices

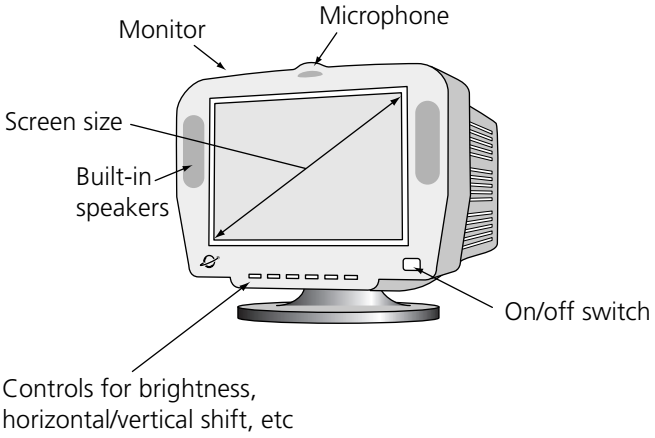
Output devices are used to present the information that the user needs in a useable form. The output that is produced may be permanent, for example, when it is on paper, or it may be temporary as on a computer screen.

In any given situation, the choice of output device will depend on the type of output required together with such factors as:

- initial cost of buying the device
- running costs
- the device's footprint
- how noisy the device is
- the quality of the output produced
- how quickly the output can be produced.

Visual display unit (VDU)

The VDU is the most common output device. Two different kinds of VDU or monitor are commonly available. A cathode ray tube (CRT) monitor works by firing a beam of electrons at a specially coated glass screen. This type of VDU will need to extend 40 to 50 cm back from the display surface to allow for the electron beam to be formed and fired. In addition, it needs a high voltage supply and fairly heavy electronic devices in order to control the way the beam hits the surface to make up the picture.



The second type of VDU is the TFT (Thin Film Transistor) screen. This is often called a flat screen monitor because the display surface is flat rather than having the slight curve needed for a CRT screen. TFT screens are used for laptop computers and other portable devices like mobile phones because they are thin and light, and do not use as much electrical power as a CRT screen. TFT screens are more expensive than CRT screens but, as their cost falls, they are becoming much more common and are gradually replacing the older CRT technology.

VDU sizes are measured across the diagonal, from corner to corner of the screen. A standard VDU is 15" or 17", but larger screens are becoming much more common. A larger screen is essential for design work and desktop publishing applications.

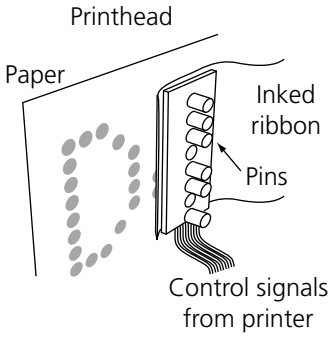
One important characteristic of a VDU is its resolution. This is the number of dots per inch that the screen can display. High resolution means a better quality display but it is more expensive.

Some of the advantages and disadvantages of VDUs are as follows:

- ✓ Low running cost.
- ✓ Silent operation.
- ✓ High-quality colour output. Animated output is possible.
- ✓ Large screen size provides good output display for DTP and design applications.
- ✗ Output is not permanent.
- ✗ Large footprint.
- ✗ CRT monitors are heavy.
- ✗ Some concern over possible health risks of CRT screens – radiation from high voltage sources inside the device.

Dot-matrix printer

A dot-matrix printer works by having a set of pins contained in the printhead. The pins are fired at an inked ribbon, hitting it onto the paper and making a dot. There is a single vertical line of pins (usually 24) and the character is built up as the printhead moves across the page. Each character is therefore made up of a matrix of dots.



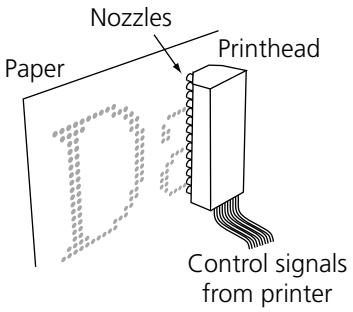
Dot-matrix printers have one advantage over ink-jet and laser printers. Since the character is formed by a pin hitting the ribbon onto the paper, they can use multi-part stationery to produce one or more copies of the document as the first copy is printed. This type of printer is therefore often used for printing till receipts. As the top copy is printed, the second and other copies are also printed because they are coated with a special pressure-sensitive material. This can only happen because of the impact of the printhead pins on the paper.

Some of the advantages and disadvantages of dot-matrix printers are as follows:

- ✓ Low purchase cost.
- ✓ Very low running costs.
- ✓ Graphics and text can be output and colour is possible using special ribbons.
- ✓ Can produce duplicate copies using special multi-part stationery.
- ✓ Slow printing.
- ✗ Noisy when printing.
- ✗ Quality is reasonable for text but graphics are poor.
- ✗ Cannot print overhead transparencies that are often needed for business presentations.

Ink-jet printer

An ink-jet printer has a printhead that fires small bubbles of ink at the paper. The image is built up using dots in the same way as a dot-matrix printer. However, the ink bubbles are small and easily controlled so the number of dots per inch can be increased to produce a much higher resolution and print quality. Typically, 4800 x 1200 dots per inch is possible, although when the ink hits the paper the resolution may be reduced as it soaks in and spreads out.



Many ink-jet printers use three different colours (magenta, cyan and yellow) together with black to produce full colour images. Some, especially designed for printing colour photographs, use even more colours. Ink-jet printers are able to print very high quality colour images using special paper, but most will produce good quality text and graphics on ordinary paper too.

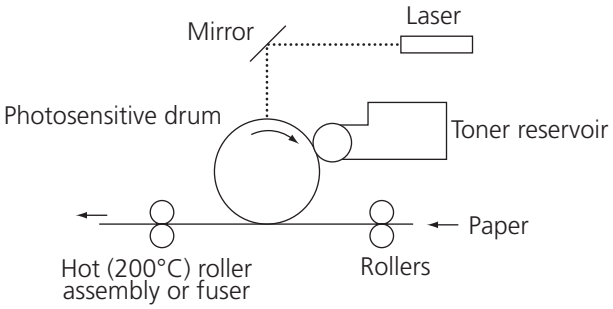
An inkjet printer using photo-quality paper will produce much better photographs than a colour laser printer.

Some of the advantages and disadvantages of ink-jet printers are as follows:

- ✓ Medium to low purchase cost.
- ✓ Almost silent printing.
- ✓ Excellent quality text and colour images.
- ✓ Can print overhead transparencies.
- ✗ High running costs.
- ✗ Faster than a dot-matrix printer but still slower than a laser printer.
- ✗ Special paper needed for best results.
- ✗ Cannot produce duplicate copies while printing top copy.

Laser printer

Laser printers work by having a laser beam scan across a special drum. Where the beam hits the drum it becomes electrically charged. The drum then rotates past a container of toner. The toner is made up of very small particles of plastic. These are attracted to the charged spots on the drum and are picked up by it. The drum rotates further and comes into contact with the paper. The toner is deposited on the paper in the pattern of the image. Finally, the paper and toner are heated so that the toner fuses onto the paper to form a permanent image.



Colour printing is possible by using black, cyan, magenta and yellow toner. Colour laser printers are about the same price as a good photo-quality ink-jet printer. Because of the way that a laser works, it is unusual to find a laser printer that takes larger than A4 paper. Some print on A3, but the cost of such a printer is high.

Laser printers produce very high-quality images, although like the previous two printers, the images are still made up of dots. Typically, a laser printer will have a resolution of 1200 dots per inch. Running costs for a laser printer are less than for an ink-jet but greater than for a dot-matrix. A small monochrome laser printer will cost about the same as a colour ink-jet printer. For most purposes, the quality will be the same but the laser will print faster and cost less to run.

Some of the advantages and disadvantages of laser printers are as follows:

✓ Medium running costs.

✓ Almost silent printing.

✓ High quality text and images.

✓ Fast printing.

✓ Can print overhead transparencies.

✗ High purchase cost.

✗ Produces ozone so has to be used in a ventilated space.

✗ Colour photos are lower quality than on an ink-jet printer.

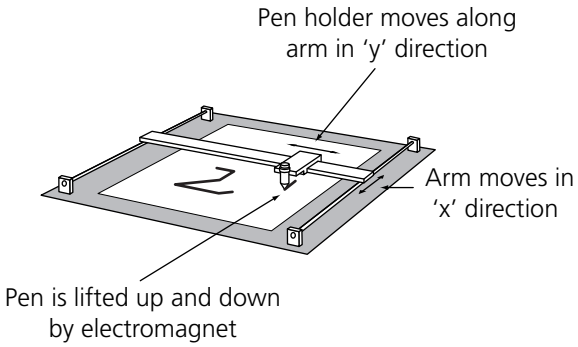
✗ Cannot produce duplicate copies while printing top copy.

Graph plotter

This is the only output device that we have described where the image is not made up of dots. Here the paper is attached to a drum that rotates, thus moving the paper backwards and forwards in one direction while a pen is moved backwards and forwards at right angles to the direction the paper moves in. The combination of movements allows any shape or pattern – including text – to be drawn on the paper.

Another design that is used is the flat-bed plotter. Here the paper is held flat and does not move. The pen is moved in two directions at right angles, usually by mounting it on an arm that can move from left to right while the pen moves along the arm from top to bottom.

Either type of plotter will normally have a holder for a number of pens of different thickness and holding different colours of ink. This allows the plotter to select the colour and thickness needed for a particular line.



A flat-bed plotter

Graph plotters produce very high quality output but they are very slow. It can take hours to produce a large complex diagram since each line and letter is drawn individually. Plotters do, however, have one great advantage over normal printers. They can be built to take large sheets of paper. This ability, combined with a high-quality accurate output, makes plotters ideal for printing architectural and design plans, although for A4-size plans, a laser would be preferred because it gives equal quality but faster output.

Some of the advantages and disadvantages of plotters are as follows:

✓ Can print on larger sizes of paper.

✓ Excellent for drawing accurate lines and text.

✗ High purchase cost.

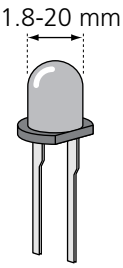
✗ Cannot reproduce photographic type images.

✗ Very slow output.

Other output devices

Two common output devices not yet mentioned are speakers and LEDs (light-emitting diodes). Speakers allow high-quality sound output from a computer and they are used for both music and speech output. Most modern desktop computer systems come equipped with speakers. Speakers depend on a magnetic field to produce their output. This magnetic field can corrupt the data on floppy disks and it can also interfere with the operation of the computer's monitor to the point where the VDU is damaged. Specially shielded speakers are used in computer systems. A simple speaker is included in almost every desktop computer even if the computer will not be used for music or speech output. This simple speaker can produce beeps to alert the user to error situations.

One other output device found on most desktop computer systems is an LED. These small lights are used to indicate that the power is on or that the disk drive is being accessed. An LED works by converting electrical energy directly to light. (Unlike a light bulb where a filament is heated until it gets white hot and gives off light.) An LED therefore requires less power than a light bulb, lasts longer and does not get hot in use.



A light-emitting diode

Key points

- Output devices display information that is produced by the computer.
- Some output devices produce permanent output, others only display the output temporarily.
- The actual output device chosen in a particular situation depends on the nature and quality of the output required, the amount of output to be produced and environmental factors such as noise and size.
- Impact printers such as a dot-matrix can print several copies at the same time.
- Plotters can produce high-quality output on large-sized paper.
- Laser printers are fast, expensive to buy, produce high-quality output with moderate running costs.
- Ink-jet printers are slower than laser printers and can produce high-quality colour output.

Questions

1 A company wants to buy a printer for its office. What factors would be important when deciding what type of printer to buy?

2 What type of output device would be most suitable for each of the following activities? Give at least one reason for each of your choices.

a General printing on a home computer, including printing letters and other documents.

b Printing in a busy office.

c Printing customer receipts in a supermarket. The printer must produce a second copy for the supermarket to keep on self-replicating paper (paper that copies through where pressure has been applied to the top copy).

d Producing lists of theatre seats that are available when a customer telephones to book a ticket.

e Producing high quality output for a design studio.

f Producing architectural drawings.

g Producing a warning that a library book that has just been returned is overdue and a fine should be paid.

h Showing that a disk drive is in use.

4 Backing storage and memory

Backing storage

Backing storage devices hold the data that the computer system is not immediately using. This type of storage is needed for two reasons.

Firstly, when a computer is switched off it loses any data that it was holding to process at that moment. If the data is to be saved for future use, it must be copied to a backing storage device. Secondly, the computer has only limited storage space to hold the data that it immediately needs. Data that is not currently needed must be stored elsewhere on a backing storage device.

There are three basic methods of storing data. One is to store it magnetically on disk or tape. The second method is to store it optically on a compact disc. The third method is to store the data electronically in a special type of chip called flash memory. When data is copied to backing storage, we say that the data is being written. When the computer retrieves the data from the backing storage for use, we say that the data is being read.

Storage devices can be categorised as serial or direct access. A serial access device allows access to stored data only in the order it is stored. If you need the tenth item of data on the device, you have to read through the first nine to get to it.

A direct access device allows you to go directly to the item of data you want without the need to read any other data. It is important to realise that data may be accessed serially even if it is stored on a direct access device. On the other hand, if data is stored on a serial device then it can only be accessed serially. All disc-based storage devices allow direct access.

Storage capacity

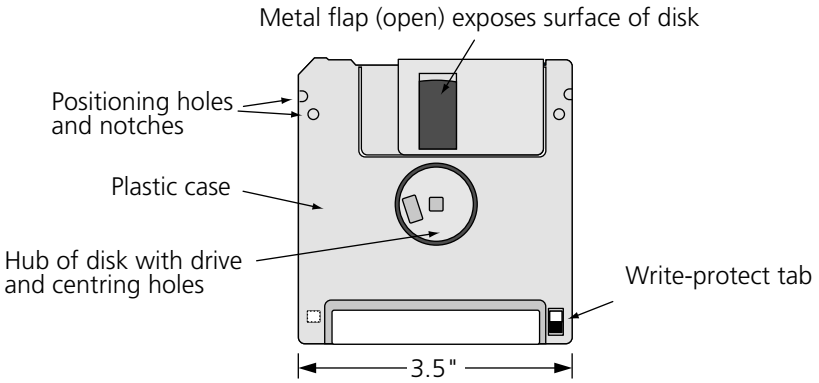
An important characteristic of any storage device is its capacity, or how much data it can store. This is measured in bytes. One byte is one character's worth of storage, so the number of bytes of storage space is a measure of how many characters' worth of data the device can hold, ie:

- 1 byte = 1 character
- 1 kilobyte = 1024 bytes (2^{10})
- 1 megabyte = 1024 kilobytes = 1 048 576 bytes (2^{20})
  – approximately 1 million bytes
- 1 gigabyte = 1024 megabytes = 1 073 741 824 bytes (2^{30})
  – approximately 1 thousand million bytes
- 1 terabyte = 1024 gigabytes = 1 099 511 627 776 bytes (2^{40})
  – approximately 1 million million bytes

Note that kilo (1024) is not the same as the normal kilo (1000). 1024 is 2^{10}, which is more useful because of the way in which computers handle data.

Floppy disk

A floppy disk is a magnetic storage medium. The disk itself is protected by a square plastic case that has a metal shutter. When the disk in inserted into a floppy disk drive, the shutter moves aside to allow a magnetic read/write head access to the surface.



Data is stored in concentric tracks on the disk. The read/write head remains stationary while the disk rotates under it as data is either written to or read from the disk. If data is to be stored or recovered from another track then the read/write head moves in or out to the necessary track. The disk cannot rotate very quickly because the head is in contact with the magnet surface. This makes a floppy disk a relatively slow storage device.

A typical floppy disk stores 1.44 MB of data. As software becomes more complex, the size of a typical computer file increases. Floppy disks were once used for back-up and for supplying computer software, but their storage capacity is rather small for modern needs and their use is becoming less common. When software is supplied on floppy disks it is not uncommon for it to need ten to 20 individual disks.

Some of the advantages and disadvantages of floppy disks are as follows:

✓ Disks are cheap to buy.

✓ Most computers have a floppy disk drive.

✓ Direct and sequential access is possible.

✗ The storage space is limited for modern needs.

✗ Easily damaged by heat, magnetic fields or dirt.

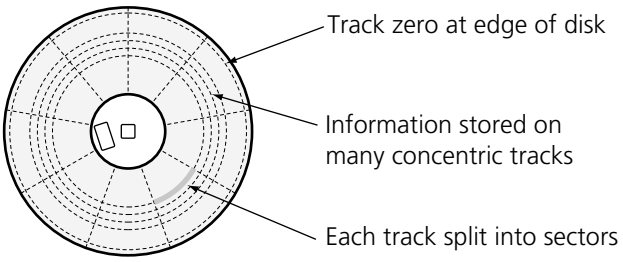
✗ Data can be accidentally erased.

✗ Access time is slow.

Hard disk

A hard disk can store much more data than a floppy disk and access times are many times faster. The hard disk on a desktop computer is held inside a sealed unit so that it is unaffected by dust. The storage capacity of this type of hard disk is constantly increasing. A typical value for a modern unit is 250 gigabytes for home or school use. On larger systems, the hard disks may hold terabytes (1024 GB) of storage.

The hard disk unit consists of a number of rigid plates mounted on a central spindle. The plates spin very quickly, typically 90 to 250 revolutions per second, and the read/write head floats on a cushion of air a fraction of a millimetre above the disk surface. Each surface has its own read/write head and these move in and out together so that the same track on each of the surfaces is available for reading or writing at the same time.



Some of the advantages and disadvantages of hard disks are as follows:

✓ Large amount of storage capacity.

✓ Fast access.

✓ Direct and sequential access is possible.

✕ Easily damaged by sudden movement or shock.

✕ Cannot be removed from the computer and taken elsewhere.

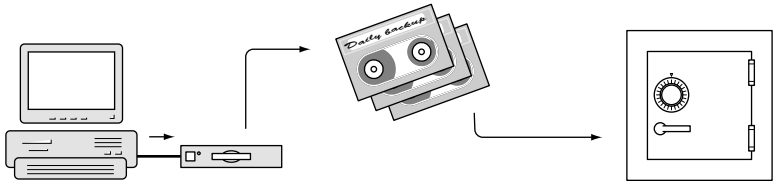
✕ Data easily lost if disk drive fails or if it is accidentally deleted.

Tape

There are a number of different tape formats used in computer systems. Large reel-to-reel tapes are used with mainframe computers and small self-contained tape cartridges are used with desktop computer systems. Tape is a sequential medium, so data has to be read from it in order. If it is used to store files then the files can only be accessed sequentially. There are applications where files need to be accessed sequentially and a tape is sometimes used in these applications.

If files are processed from a tape then each file will be stored on a different tape. This is necessary because tape is a sequential medium so the computer would not be able to move directly to the second or third file on the tape without reading through the first. This would slow processing down.

The most common use of tapes on mainframe and small computer systems is for back-up. Tapes can store large amounts of data and are comparatively cheap. It is possible to copy the contents of a large hard drive onto a single tape. The tape can then be removed from the tape unit and stored somewhere safe. A different tape could be used next time back-up is done so that several back-up versions can be kept.



Data is backed up onto tape and then put in a safe place

Some of the advantages and disadvantages of tapes are as follows:

- ✓ Large amount of storage capacity.
- ✓ Tapes are cheap to buy.
- ✓ Tapes can be removed from tape unit for safe storage.
- ✗ Sequential access only.
- ✗ More bulky than disk.
- ✗ Vulnerable to magnetic fields or accidental deletion of data.

CD-ROM

The letters ROM stand for 'read only memory' and indicate that the data stored on the CD can be read but not changed. CD-ROMs store data optically. This means that the data cannot be accidentally erased or lost by exposure to a magnetic field.

CD-ROMs can store just over half a gigabyte of data and they allow direct access. They are a little slower than magnetic disks because they do not spin as quickly. They are useful for storing data that does not need to be changed, such as encyclopedia and reference material. Their capacity is large enough to include space for storing moving picture sequences and sounds in addition to the more usual data.

Software is increasingly supplied in CD-ROM format. Manufacturers prefer it because CD-ROMs are cheaper to produce and package than floppy disks. They also have the advantage that copying is more difficult so that casual pirating of the software is less likely. For the user, the installation process is easier with only one disc to insert into a CD drive and there is less chance of damaging the disc or corrupting the data on it.

Some of the advantages and disadvantages of CD-ROMs are as follows:

- ✓ Large amount of storage capacity.
- ✓ Data is permanent – no accidental change or deletion.
- ✓ Production is very cost-effective when a large number of copies are needed.
- ✓ Direct and sequential access possible.
- ✗ Access is not as fast as for magnetic disk.
- ✗ Cannot write your own data to the CD.
- ✗ Set-up costs for manufacture are high so small-scale production is not cost-effective.

CD-R

CD-R stands for 'compact disc – recordable'. A special CD-R drive is able to record data onto this type of disc (it can also read ordinary CD-ROM discs). The disc is supplied with no data stored and the user can copy data from their hard drive or from CD-ROM onto the CD-R.

The surface of the disc contains a special dye that is temperature-sensitive. The laser in the CD-R writer device heats the surface, storing the data by permanently changing the dye. A lower intensity laser beam, which does not affect the dye, is used to read the disc.

The resulting disc can be read by most ordinary CD drives, so this is a good way of distributing large data files. CD-R is also useful for archiving data (ie storing old data that is no longer needed for processing but that might need to be used some time in the future).

CD-R is also used for small-scale distribution by recording studios and software producers. It would be used where the number of copies required is small so that the set-up costs for CD-ROM production would make distribution on ordinary CDs too costly.

Some of the advantages and disadvantages of CD-Rs are as follows:

- ✓ Can be read by ordinary CD drives.
- ✓ Data is permanent.
- ✓ Both the CD writer and the CD-R discs are reasonably inexpensive.
- ✓ Direct and sequential access possible.
- ✗ Access is not as fast as for magnetic disk.
- ✗ The disc cannot be reused if the data on it is no longer needed.
- ✗ Disc surface is more easily damaged than a CD-ROM disc.
- ✗ Require special-purpose CD writer.

CD-RW

Compact disc rewritable (CD-RW) discs use crystalline material to store data. Heating the material changes the way it reflects light and in this way it stores the data. The change is not permanent, however, and the crystal structure can be restored to its original state, allowing the disc to be reused. There is a limit to the number of changes that the crystals will undergo (over 5000 cycles) so the disc has a limited lifetime.

CD-RW discs can be written to and read by the same drives used for CD-R and CD-ROM discs. They are slightly more expensive than CD-R discs and are much slower to write data to. A typical application would be for backing-up data on a desktop computer.

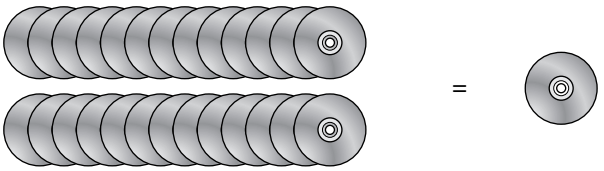
Some of the advantages and disadvantages of CD-RWs are as follows:

- ✓ Disc can be reused.
- ✓ Can be read by a normal CD drive.
- ✓ Direct and sequential access possible.
- ✗ Access is not as fast as for magnetic disk.
- ✗ Discs are more expensive and slower than CD-R.
- ✗ Requires special-purpose CD writer.

DVD-ROM

Digital versatile discs (sometimes known as digital video discs) can store a minimum of 4.7 GB of data. They are the same size as a CD-ROM, and indeed, a DVD disc drive can read CDs as well as DVDs.

A DVD stores more data than a CD by packing the data closer together on the disc. In addition, a DVD can be made up of two layers, each storing 4.7 GB. A two-layer disc can therefore store 9.4 GB of data. Greater capacity than this is possible, since DVDs can be double-sided, giving the possibility of a total of 17 GB of storage using two layers on each side – the equivalent of 26 CD-ROMs.



26 CD-ROMs at 650 MB each 1 DVD at 17 GB

A 4.7 GB DVD can store over two hours of high-quality video. The entire *Encyclopedia Britannica*, which, in its printed form consists of 32 volumes and takes up over half a metre of shelf space, can be distributed on a single DVD-ROM with added video animations to improve the information provided.

Some of the advantages and disadvantages of DVD-ROMs are as follows:

- ✓ Very large amount of storage space compared to CD.
- ✓ DVD drives can read CD discs.
- ✓ Direct and sequential access possible.
- ✓ Cost of DVD drive is not much greater than cost of CD drive.
- ✓ Access is not as fast as for magnetic disk.
- ✗ Not all computers have a DVD drive.
- ✗ If a disc is accidentally scratched, the data on it could be lost.
- ✗ Data cannot be changed.

DVD-R

DVD-R discs can be written to once (the R stands for 'recordable'). They can be read by ordinary DVD drives but need a special DVD writer drive to record them.

DVD-Rs are ideal for long-term storage of data that does not change – for example storing family videos or photographs. Like CD-R, they are also ideal for small-scale distribution of files that are too large for a CD and where the cost of the equipment need to manufacture a DVD-ROM would not be justified.

Some of the advantages and disadvantages of DVD-Rs are as follows:

- ✓ Large amount of storage space compared to CD.
- ✓ DVD writer drives can also read and write CDs.
- ✓ Direct and sequential access are possible.
- ✓ Data is permanent.
- ✗ Access is not as fast as a magnetic disk.
- ✗ Not all computers have a DVD writer.
- ✗ If a disc is accidentally scratched, the data on it could be lost.
- ✗ Disc cannot be reused if the data is no longer needed.

DVD-RW

DVD-RW discs can be written to and erased many times. They can be read by ordinary DVD drives but need a special DVD writer drive to record them.

Some of the advantages and disadvantages of DVD-RWs are as follows:

- ✓ Large amount of storage space compared to CD.
- ✓ DVD writer drives can read and write CDs.
- ✓ Direct and sequential access are possible.
- ✓ Disc can be reused.
- ✗ Access is not as fast as a magnetic disk.
- ✗ Not all computers have a DVD writer.
- ✗ Slower to write to than DVD-R.
- ✗ Discs are more expensive than DVD-R.

DVD-RAM

DVD-RAM discs are similar to DVD-RW. However, they are not as generally compatible as the other types of DVD. They are held in a special caddy which protects the disc from damage.

A DVD-RAM disc can only be read by a compatible drive. Some of the advantages and disadvantages of DVD-RAM discs are as follows:

- ✓ Large amount of storage space compared to CD.
- ✓ Data can be written as well as read.
- ✓ Direct and sequential access are possible.
- ✓ Disc is protected by the caddy so it is unlikely to be scratched or damaged.
- ✗ Access is not as fast as a magnetic disk.
- ✗ Can only be used in a drive that is compatible with DVD-RAM.
- ✗ More expensive than other DVD formats.

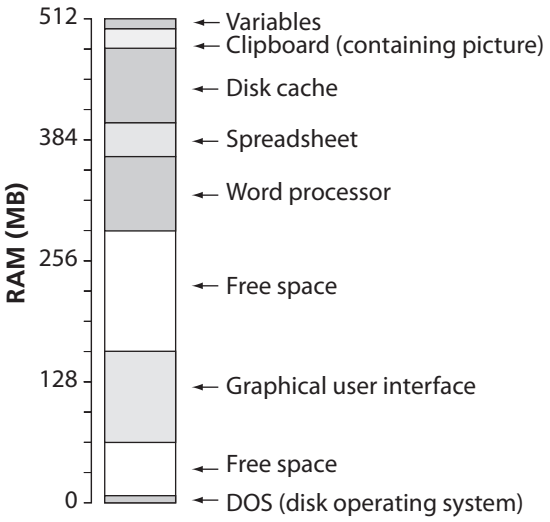
Memory

Up to now, we have been looking at the ways in which data is stored when not actually in use by the computer system. These types of storage were called backing storage.

When data is needed for processing, it must be copied from the backing store into the computer's memory. Data in the memory is directly available to the computer for processing.

Random access memory (RAM)

RAM is where the data is copied to when it is loaded in from the backing store. The computer processes the data in RAM and, if necessary, copies the results from RAM back to the backing store.



When you word process a document, both the document and the word-processing program must be present in the computer's memory. When you start up a program, the computer will copy the program from the hard drive into RAM. When you load a file to use with the program, the file will be copied from the hard drive into RAM. When you save the document, it will be copied back from RAM to the hard drive. There is no need to save the program since the data that makes it up has not changed.

A typical small computer will have about 500 MB of RAM. When the computer is switched off, the data stored in the RAM will be lost. This is one reason why backing storage is necessary. We say that RAM is volatile because it loses the data when the power is turned off.

Read only memory (ROM)

ROM is memory stored in a chip. The data that it stores is put into the chip when it is manufactured. This data cannot be changed and it is not lost when power to the chip is turned off. The data stored in ROM is available to the computer in the same way as data stored in RAM.

RAM	ROM
Type of computer memory	Type of computer memory
Volatile	Non-volatile
Stores user's data and software while being processed	Stores manufacturer's data and software needed to start up computer
Data can be changed	Data cannot be changed

When a computer is first switched on, it needs to load a special program called the operating system from the hard drive. The operating system contains all the instructions that the computer needs to be able to act like a computer. However, the computer needs a set of instructions in order to load the operating system. These instructions are called the BIOS – Basic Input/Output System. ROM was once used to store the bootstrap program, but this had the major disadvantage that, if an upgrade were needed, the ROM chip had to be removed and a new one inserted, since the contents of a ROM chip could not be changed. This problem was overcome with the development of flash memory.

Flash memory

Flash memory combines some of the characteristics of RAM and ROM. The data stored can be changed, just like RAM memory. However, when the power is turned off, the contents of flash memory are not lost – just like ROM memory. Flash memory is used both as part of the computer's memory and as backing storage.

As mentioned earlier, ROM chips were once used to store the instructions used to start a computer when it is first switched on (called the BIOS). As computers became more complex, manufacturers found it necessary to update the BIOS software from time to time. When ROM was used, the only way to update the BIOS was to remove the old ROM chip and insert a new one. Now that flash memory is used instead, users can download and update the BIOS software in their computer without changing the memory chip.

Although flash memory is ideal for storing the BIOS software, it cannot be used to replace the main part of a computer's memory. This is because only RAM chips can provide the high-speed access needed for this function.

Flash memory is also used as backing storage in the form of memory sticks which, when plugged into a computer's USB port, appear as a removable disk drive. Files can be copied to the drive and then transferred to another computer. This type of device comes in a variety of storage sizes ranging from 128 MB to 4GB, allowing large files to be transported from one computer to another. A flash memory stick has the advantage over optical media that it is faster to write the data and less likely to be damaged in use. Also, since most computers have a USB connector, no additional hardware – such as a CD or DVD writer – is needed. Digital cameras also use flash memory cards to store pictures.

Some of the advantages and disadvantages of flash memory as backing storage are as follows:

- ✓ Large amount of storage space.
- ✓ Small physical size.
- ✓ Direct and sequential access are possible.
- ✓ Not very susceptible to physical damage.
- ✗ Data could be accidentally deleted or overwritten.
- ✗ May be lost or mislaid.
- ✗ Older computers may not have a USB port or may need special drivers to access the device.

RAM, ROM and volatility

Initially the terms RAM and ROM were applied only to memory chips. Even when used only for the two types of memory chip, the terms were confusing. Random access means being able to access data directly rather than having to read through the data sequentially. ROM memory can be accessed randomly, just like RAM.

ROM is perhaps the more sensibly named because anything called ROM has data that can be read but not changed, ie it is read only. The term ROM was then used to describe CDs that stored data that could be read but not written. This use was a little confusing since CDs are not memory strictly speaking; they are backing storage. ROM then became generally used for any data storage medium where the data could not be changed – hence DVD-ROM.

To make things worse, the term DVD-RAM was then used to describe rewritable DVDs. So RAM has taken on the meaning of data storage where the data can be changed. Note that while RAM memory chips are volatile, DVD-RAM is not.

The table on the following page gives a summary of all the data storage media, showing whether or not they allow random access, whether they are recordable, rewritable or volatile.

Medium	Random access possible?	Data can be read	Data can be written	Data can be rewritten	Volatile
Floppy disk	Yes	Yes	Yes	Yes	No
Hard disk	Yes	Yes	Yes	Yes	No
Magnetic tape	No	Yes	Yes	Yes	No
CD-ROM	Yes	Yes	No	No	No
CD-R	Yes	Yes	Yes	No	No
CD-RW	Yes	Yes	Yes	Yes	No
DVD-ROM	Yes	Yes	No	No	No
DVD-RAM	Yes	Yes	Yes	Yes	No
RAM memory	Yes	Yes	Yes	Yes	Yes
ROM memory	Yes	Yes	No	No	No
Flash memory	Yes	Yes	Yes	Yes	No

Key points

- Backing storage holds the data that the computer does not currently need.
- Data that is currently being processed is held in memory.
- Backing storage is either magnetic or optical.
- Memory chips are either RAM or ROM.
- RAM is volatile memory, ROM and flash memory are non-volatile.
- Disk storage allows direct or sequential access, tape storage only sequential.
- CD storage is suitable for reference material and software installations.
- DVD storage is suitable for video, large encyclopedias, very large amounts of data and back-up.

Questions

1 What do ROM, RAM, flash memory, hard and floppy disks, magnetic tape and optical discs all have in common?

2 a Explain the meanings of the words volatile and non-volatile when applied to computer storage media.

b Which of the media in Question 1 are non-volatile?

3 Flash memory and RAM chips make up the computer's memory. The data stored in the flash memory is initially put in by the manufacturer and is not likely to be changed very often. The data stored in a RAM chip can be changed and it is lost when the power is turned off.

a Which type of memory chip stores the computer program that runs when the computer is first turned on? Give a reason for your answer.

b Which type of memory chip stores a document while it is being word-processed?

c When a word-processed document is completed, it is saved to a hard disk drive. Give two reasons why the hard disk drive is needed.

4 Why are optical discs often referred to as CD-ROMs?

5 A random access medium allows data to be recovered in any order. Only one of the media mentioned in Question 1 does not allow random access. Which one is it?

6 What type of backing storage would be most suitable for each of the following situations? In each case give a reason for your answer.

a Taking a spreadsheet file home to carry on working on it.

b Storing details of customers and parts for a local garage.

c Backing-up the hard disk of a home computer.

d Distributing computer training materials that include about 90 minutes of video.

e Distributing a parts catalogue consisting of about 200 MB of data to many thousands of customers.

5 Software

What is software?

A computer system is made up of hardware and software. The hardware is the physical components like input, output and backing store devices. Software is the computer programs that instruct the computer to perform particular operations. Software consists of very simple instructions that tell the computer what to do with the data that it is processing.

Operating system

Systems software is provided to ensure that the hardware works as a computer and it is usually supplied with the computer. The most important type of systems software is a special program called the operating system. This program is loaded and run when the computer is first started up. It performs a number of essential tasks and it remains loaded in memory all the time that the computer is switched on. It is responsible for controlling and managing the way in which the different components of the computer system communicate and interact. The user's programs (applications software) will call on the operating system to carry out many basic tasks. The operating system's tasks include:

- **Memory management** – Allocating memory to programs and making sure that one program does not interfere with memory allocated to another.
- **Communication** – Handling communication between the different parts of the system so that they work together.
- **Data transfer** – Moving data between the different parts of the system, eg transferring data from hard drive to memory. Handling input and output operations.
- **Processor management** – Deciding which program should be given processor time and for how long.
- **Security** – Detecting, handling and reporting error situations to minimise loss of data. Handling log-in for password protected systems.

For example, if a word-processor program needed to print a page of text, it would pass the output to the operating system. The operating system would communicate with the printer to make sure that it was available and ready to print. It would then pass the output to the printer.

Since an operating system is a computer program, it is possible to run different operating systems on the same computer and the user can select the operating system that is most appropriate at the time. This is an important consideration because a particular application that the user has bought may require a particular operating system.

The operating system will determine the way in which the computer behaves. Two important types of operating system are multi-tasking and multi-user.

Multi-tasking operating systems allow several programs to be loaded and apparently running at the same time. For example, one program might be accepting input from the keyboard while another is reading data from a disk, processing and printing it.

In order to achieve this, the operating system will allow each of the different programs access to the central processing unit (CPU) in turn. The CPU will actually process one program's data at a time. When that program cannot continue immediately – perhaps because it is waiting for data to be found on a hard drive – then the operating system will hand the processor over to another program that can continue. In this way, the CPU, which is the fastest part of the computer, is kept busy and does not have to wait for data transfers to or from slow peripherals because it can get on with processing data for another program.

A multi-tasking operating system will need to ensure that two programs do not try to access the same peripheral at the same time, thus preventing, for example, printouts from two programs from being mixed up. It will need to manage memory so that one program does not interfere with the memory allocated to another. In large computer systems, it will also select the next program to load when it detects that there are resources available to run it.

Multi-user operating systems allow more than one person to use the computer at a time. The computer will be connected to a number of terminals. The operating system may allocate a short amount of time to each terminal. During this period it will check the terminal to see if it needs processor time. If it does, that terminal's job will be processed for a short length of time. At the end of that period, the operating system will move on to the next terminal so that each is checked and given processor time in turn. This is the system used in supermarkets to allow the shop's computer to handle several checkout terminals at once.

A multi-user operating system will need to identify each user who logs on to a terminal and ensure that they each have access to their data. It will also need to ensure that users cannot gain unauthorised access to other users' data and software.

Utilities

Utility programs allow the user to carry out various computer-related tasks. For example, the user may need to format a floppy disk or find the location of a file on the hard drive. Different utility programs will allow the user to carry out these tasks.

Although utility programs are part of the systems software, they are not usually part of the operating system. The operating system is always loaded while the computer is running. A utility program will usually be loaded and run only when the particular task it performs needs to be carried out.

Applications software

Systems software is important because it makes the computer hardware work as a computer system. However, the computer user will have bought the computer system to perform one or more tasks. The software that makes the computer perform these user-related tasks is called applications software.

Some applications software may be written to perform a particular specialised task, such as stock control or the payroll for a particular company. Other applications, such as a word-processor program or spreadsheet, may be general purpose or generic. Generic software can be used in a variety of ways for different purposes. A word-processor program could be used to produce posters, prepare legal documents or write a school assignment.

Non-generic software (task-specific)	**Generic software** (general purpose)
Payroll	Word processor
Game	Desktop publishing
Stock control	Database
Customer billing	Spreadsheet

Nearly all applications programs can be customised. 'Customising' means allowing the user to set up the application in a way that suits them. Examples of customisation include setting up special dictionaries for a word processor, choosing the format for currency or dates and setting default fonts and background colours.

Software needs to be customisable because it will often be used by a large number of users, each having different needs. For this reason, generic packages such as word processors, spreadsheets and databases usually include a large number of configuration options. A non-generic application, written for one specific purpose, will normally have fewer configuration options because there will be a more limited user base and the tasks that the users will carry out are more clearly defined.

Sometimes a user's software needs cannot be met by an existing package. In this case, software may be specially written for the user. This is called bespoke software and the user should end up with an application that exactly matches their needs. However, software development costs are high, so this is an expensive option. In addition, it can take months or even years for software to be developed.

Presenting information

The purpose of most applications software is to produce information. To be useful, the information must be presented in a way that depends on both what the information is and who it is to be presented to.

Printed information is useful if copies are to be distributed to people or if the information is to be filed for future reference. Company accounts, for instance, would be printed both as a permanent record and so they can be distributed to a number of different people.

Information that is not needed permanently can be printed on a VDU screen. An example of this would be ticket booking information for a theatre, where the booking clerk needs to see a list of available seats for a particular performance but no permanent record is required.

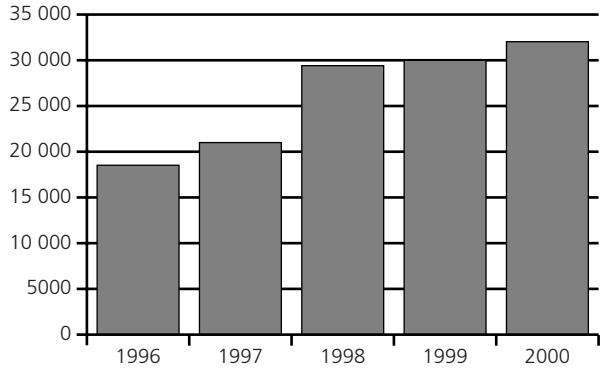
Presentations to groups of people often make use of VDU screens or, for larger groups, projectors. Use of computer-generated presentations allows the possibility of multimedia presentations which can include a mixture of text, sound and graphics such as pictures, charts and graphs. The application Microsoft® PowerPoint is designed to allow this type of presentation to be put together easily.

Information can be made easier to use by presenting it in an appropriate manner. The diagrams below show the same information presented in different ways. The information below is the number of GCSE examination entries for Information and Communication Technology.

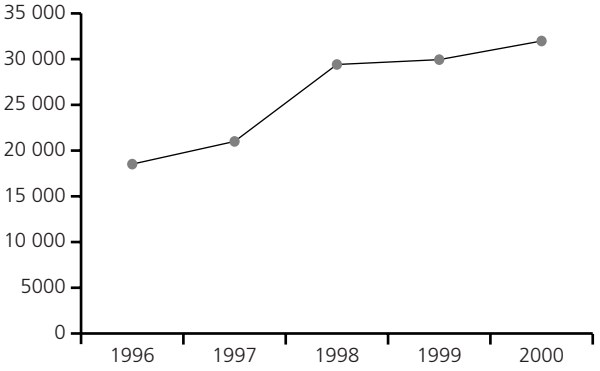
Presenting the information in table format allows the user to find the actual number of entries for a given year easily. However, it does not so obviously show the trend nor allow easy comparison between one year and the next.

Year	Entries
1996	18 270
1997	21 612
1998	29 730
1999	30 021
2000	32 742

When the same information is presented as a bar chart, it is easy to compare one year's figures with another. However, it is no longer easy to see the exact figure for a particular year.



A line graph makes it easy to spot the trend. Comparison between one year and another is no longer quite so obvious but, with a large enough scale, reasonably accurate figures can be read for a particular year.



A large number of variations on these graphs and charts is possible. If you needed to compare proportions – for example, the proportion of fibre or fat in a prepared food – then a pie chart would be the most effective format.

Modelling and simulation

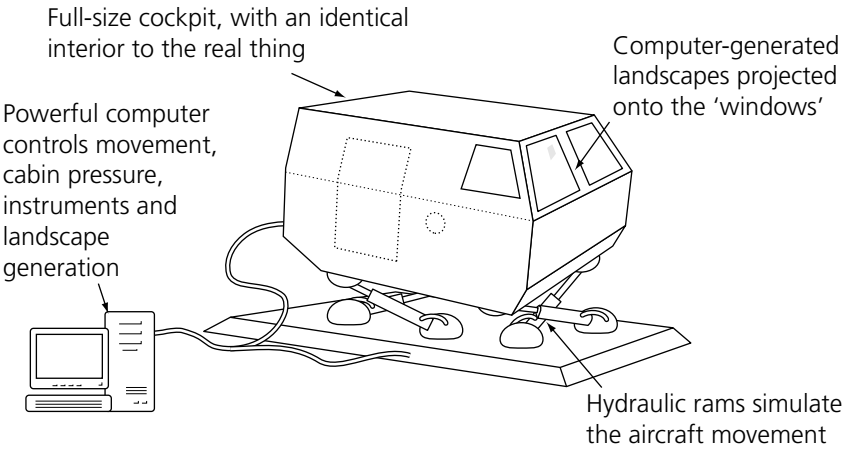
You might normally think that a model is a small-scale version of a real-life object. The model looks and perhaps behaves like the object that it is modelled on. A computer model is software that behaves like a real world equivalent.

The government uses a computer model of the country's economy to predict what would happen to industrial output and unemployment if particular measures, such as a change in interest rates or taxation, were taken.

Computer modelling software allows the user to try out different situations to see what the effects would be. The user can experiment in situations where real-life experiments would be impossible, too expensive or simply dangerous. A computer model of a nuclear power station could be used to predict what might happen in various emergency situations; to do this with a real nuclear power station would be potentially disastrous.

All computer models are made up of sets of rules. When data is input to the modelling software, the rules are applied to predict what would happen. Spreadsheets are particularly good to use as the basis of many models, especially financial models, although complex situations are often modelled using especially written applications software.

Simulations are very similar to models. In fact, a model is a simulation of whatever it is modelling. As computer power develops, realistic simulators have become possible. Virtual reality devices give the user the impression of really being in the situation being simulated. A good example of this is a flight simulator where projectors produce the cockpit view that would be seen in real life and hydraulic equipment tilts the cockpit to give the effect of really flying an aircraft. Simulators, like models, allow dangerous situations to be looked at safely. Pilots regularly train in emergency drills using flight simulators.



The development of virtual reality equipment is likely to lead to the increased use of simulators.

File formats

It is often necessary to transfer data from one application to another. A picture may be captured and edited using a specialised photo-editing application and then imported into a word-processed document. This can only happen if the photo editor and the word-processor application share a common format for storing the picture data.

Even greater problems could arise if files are being transferred from one computer to another because the two computers might be running completely different applications. Since this is a common problem, a number of standard file formats have been created. These formats will be understood by the relevant applications software.

The format that a file is stored in is usually indicated (in the Windows operating system) by a three-letter extension that is placed after the filename. The table on page 36 lists some common file formats for the various types of data that applications use:

Type of data	File type	File extension	Description
Text	Text	.txt	The basic text format stores the characters that make up the document. No data about the layout or fonts is stored. It can be read by any word processor or text-editing application.
	Rich text	.rtf	Stores additional data about fonts and layout. This type of file can be read by most word-processor applications.
Sound	MPEG-1 Audio layer 3	.mp3	MPEG stand for moving pictures expert group. This file format stores compressed sound data. It is used to distribute sound tracks from CDs and other recorded sound. MP3 files can be read and played by a variety of specialised applications.
	WAVE	.wav	This sound format was developed by Microsoft® for use in the Windows operating system. The different sounds produced by Windows are stored as .wav files.
Picture	Bitmap	.bmp	Strictly speaking, a bitmap image file uses one binary digit to represent one point on an image as either black or white. It can therefore only represent monochrome images. In practice, the .bmp format represents coloured images by using more than one bit to store data about the point on the image. Bitmap images are not compressed and so picture files can be very large. This file format is readable by most picture-editing applications.
	Joint photographic experts group (JPEG)	.jpg	A compressed file format used for storing picture data. This format is useful for storing photographic images but does not work well for black and white images or drawings. It is commonly used to store pictures on Web sites and is readable by most photo-editing software.
	Graphics interchange format	.gif	Used, like JPEG files, to store image data in a compressed format. It does not compress photographs as well as JPEG format, but gives better results for block colours and line drawings.
Other	Hypertext markup language (HTML)	.htm .html	A text file which uses a special language to describe the layout of a Web page. HTML files can be understood by Web browsers, which will display the file as a Web page.
	Comma separated values	.csv	A text file which consists of records that can be input directly into almost any database application. Each line of the file represents a single record and the individual field values are separated by commas – hence the name.

Key points

- A computer system is made up of hardware and software.
- Computer programs are made up of sets of instructions that the computer follows and are called software.
- There are two types of software – applications software and system software.
- Applications software is written to make the computer do a particular task for the user. It can be configured to suit the user's needs.
- Systems software is written to make the computer hardware work.
- The operating system is a part of the systems software and it controls and manages the computer system's resources.
- Computer models and simulators use sets of rules to predict how an object or system will behave in real life.
- Standard file formats allow data to be transferred between different applications software and also between different computer systems.

Questions

1 A word processor is a particular example of applications software. Give three other examples.

2 A computer's operating system is a program and it is stored on the hard disk. A special program, called a bootstrap loader, is present in the computer's memory and is run when the computer is first switched on. The bootstrap loader loads the operating system program from the disk into the computer's memory. This is called booting the computer.

   a What type of memory chip must the bootstrap loader program be stored in? Give a reason for your answer.

   b What type of memory chip should the operating system be loaded into? Give a reason for your answer.

3 A user is running a word-processing application. The computer has the operating system program and the word-processor program stored in memory. Which of these two programs will be responsible for:

   a accepting input from the keyboard?

   b deciding which line in the text will be the last one on a page?

   c storing the word-processed file on disk?

   d sending output to a printer?

   e performing a spell-check on the document?

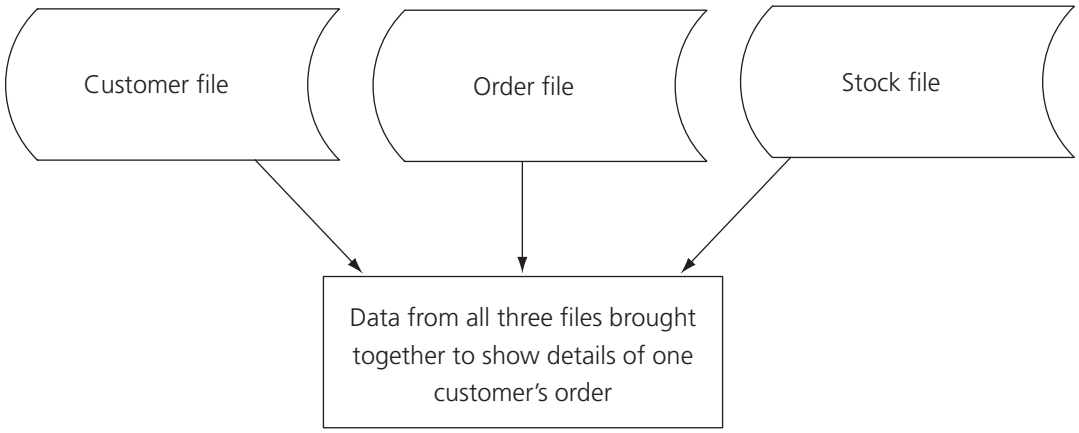
   f displaying the mouse pointer on the screen?

4 Mary has taken a photograph that she wants to email to her brother in Australia. What will she need to consider when she downloads the picture to her computer and prepares the email?

6 Databases

What is a database?

A database is a collection of related or linked files that store the data that the end user needs to process. Different databases will have different files, depending on the user's processing needs. As an example, consider a company that takes orders from customers and supplies them with goods. This company may have a customer file, an order file and a stock file. These files will be linked so that data from each of them can be brought together to provide information. The set of linked files will form the company's database.



Combining data from files

The customer file will store details of each customer and the stock file will store details of each stock item. The order file will be linked to both the customer file and the stock file so that, for a particular order, the customer's details and the stock details can be found in the customer and stock files.

Files, records and fields

Each file in a database stores data about one type of thing. In relational databases, like Microsoft® Access, the files are called tables. A file is made up of records.

Each record in the file stores data about one occurrence of the thing that the file is holding data about. For example, in a customer file, each record will store data about one customer. Each record in a particular file has the same structure; it stores the same pattern of data as every other record, although the actual data stored varies from record to record. If we think of the file as a table then a record will be one row in the table.

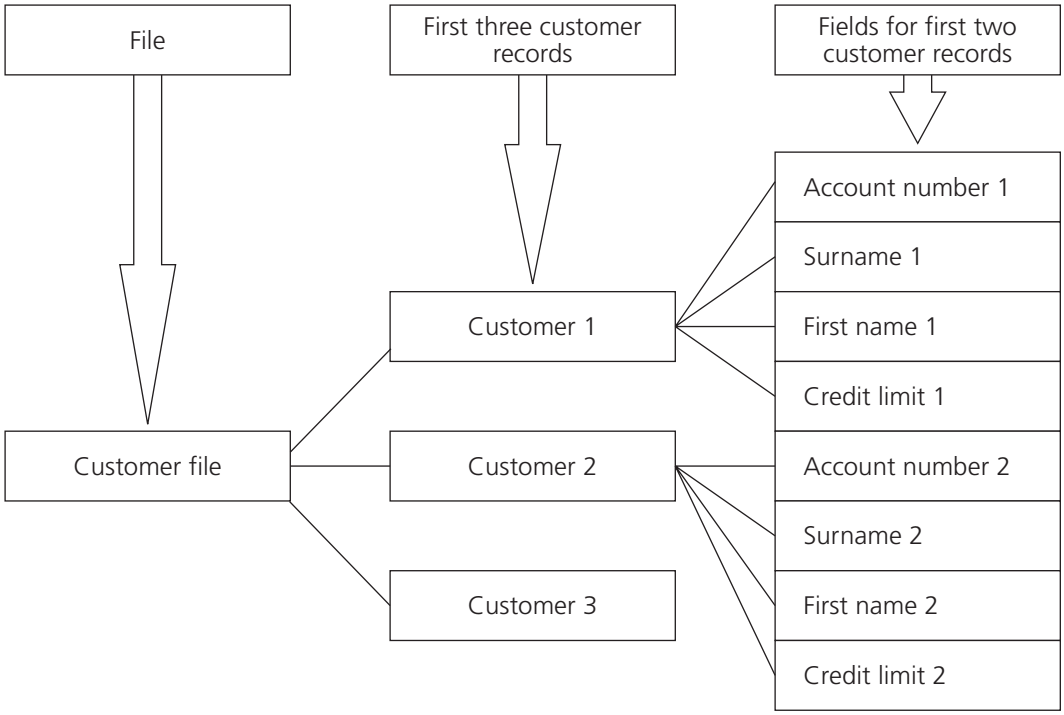
The records in a file are made up of fields. Each field contains one item of data. In a customer file, each field in a customer record would store one item of data about the customer. One field might hold the customer's surname, another their telephone number and so on. Each field is given a name that describes the data that it holds. We say that the customer record's has a surname field, a telephone number field, etc. Because many database programs do not allow spaces to be used in field names, we often separate different words in a field name by using an underline character. An alternative is to start each word with a capital letter. If we think of the file as a table then a field will be one column in the table.

Key field

It is usually essential to be able to identify a particular record in a file. In a customer file there may be several customers with the same name and it will be important to identify which of them, for example, owes you money.

A special field, called a key field, is used to identify each record in the file uniquely. Each record has its own unique value for the key field data. It is very unusual for a key field to occur naturally. In a customer file, two customers might have the same name or the same date of birth or even the same address.

You have to be absolutely certain when setting up a key field that there will never be two records with the same key field value. The only way to be sure of this in almost every case is to make up a key field. Usually a made-up key field will be a series of digits or perhaps digits and letters. Account number, stock number, payroll number and catalogue number are all examples of made up key fields. Even though these key fields are called numbers, they often include letters.



A traditional view of file structure

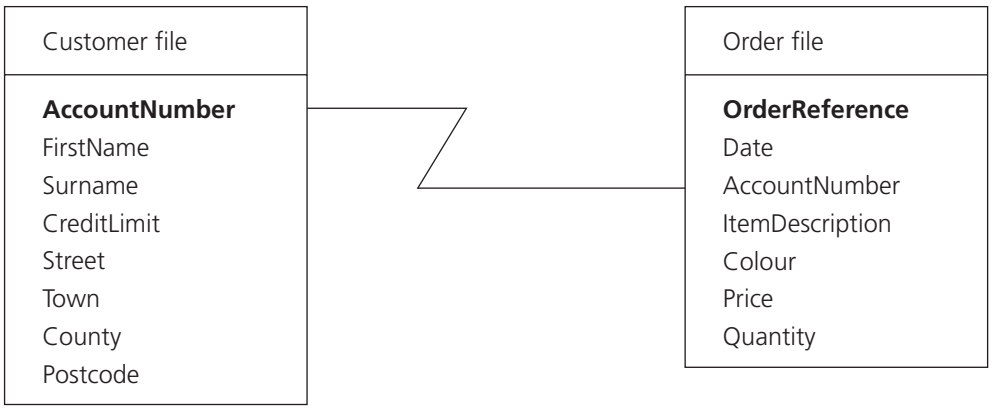
AccountNumber	Surname	FirstName	CreditLimit
Account number 1	Surname 1	First name 1	Credit limit 1
Account number 2	Surname 2	First name 2	Credit limit 2
Account number 3	Surname 3	First name 3	Credit limit 3

A table view of the same file structure

Linking files

The key fields are used to identify a record uniquely but they also serve another purpose. They can be used to link different files together. In the customer table on the previous page, we saw a customer file with account number as the key field. Now suppose a customer places an order. To make things easier we will assume that a customer can order only one item of stock at a time. The fields needed for the order must include the order date, the item and quantity ordered and the customer's details. These fields will make up a record in the order file.

However, the order file does not need to store all the customer's details since these are already stored in the customer file. All that the order file needs is some way of linking to the correct customer's details in the customer file. This can be done if the order file stores the account number. Given the account number, all the necessary data about the particular customer can then be found from the customer file. The relationship between the two files is shown in the illustration below. Order reference is the key field for the order file.

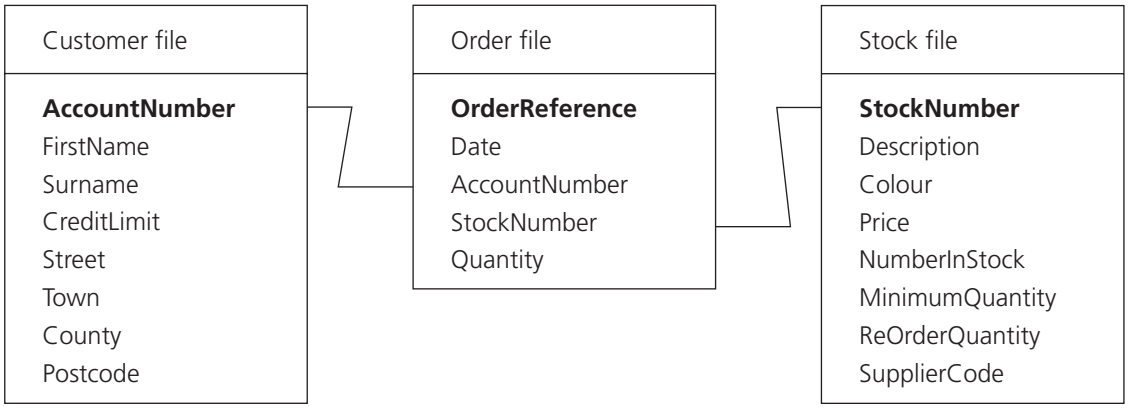


Linked customer and order files

Linking the files like this saves storage space because data is not duplicated. Without the link, we would have to store some of the customer data twice, once in the customer file and again in the order file.

There is, however, a more important benefit in storing the data once. If a customer changes address then, with the link in place, we only need to update the data in one place. If the same data were stored in several different places then one copy might be updated and another not. The customer address, for example, might be correctly stored in the customer file and incorrectly stored in the order file. By using a link based on the key field, we can store the data once, ensuring consistency.

Looking at the file structures in the illustration above, you may notice that the order file stores the description, colour and price of the item that the customer has ordered. This data will also be stored in the stock file. We can remove the duplication by storing the StockNumber (the stock file key field) as a link to the stock file. Our final structure looks like the illustration on the next page.



Three linked files

Field types

When a database is designed, the designer will decide what type of data is to be stored in each of the fields. When the database is implemented, the software will allow the data type of each field to be specified. The field types available depend on the database software that is being used to implement the database. Some common field types are as follows:

- **Text** – This field type stores any characters including digits. For a text field, it is usually possible to specify a maximum number of characters that can be used. For a surname field, you might use a 25-character text field. This would mean that a surname with more than 25 characters would be cut short. When deciding what the maximum is to be, you must allow for the longest possible occurrence of the text.
- **Number** – There is a variety of different number types available. Most databases allow you to specify integer (whole numbers) or real (numbers including a fractional part) and within these two groupings there will be a variety of types, depending on the range of the numbers to be stored.
- **Counter** – A counter field is a special type of number field. If chosen, then the database software will automatically put a number in this field, starting at one for the first new record and counting up. A counter field can be used as a key field because a new value, unique to the record being entered, is created as the record is created.
- **Date and time** – These fields store dates and times and usually allow date and time calculations to be performed on the data they hold.
- **Yes/No** – This type of field (also called true/false) is used when the data to be stored can only have one of two values. A yes/no field type could be used to store a person's sex, for example.

There are many advantages to choosing the field type when setting up a database. With the field type chosen appropriately, the database software will be able to process the data in the field correctly. Also, the software will be able to detect if inappropriate data is being entered and warn the user. A further advantage is that, if field types are properly thought out at the design stage, then the data will be stored efficiently.

Coding data

Data is often coded to reduce the amount of storage space needed and also to speed up both the entering of data and data searches. Coding is when a short combination of characters and/or numbers is used to represent the actual data. For example, eye colour might be coded as:

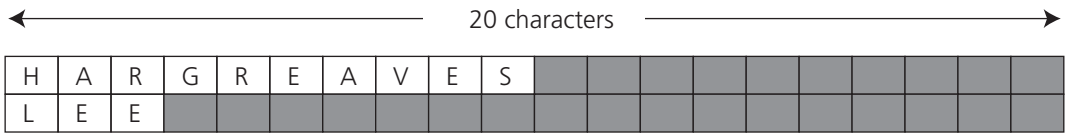
- Blue = Bu
- Green = Gn
- Brown = Br
- Grey = Gr

Coding is useful but it does have some disadvantages. Data may not fit the list of available codes exactly and so it will lose precision. For example, when coding eye colour, blue-grey eyes could not be coded accurately if only codes for blue and grey existed.

Another problem is that anyone wanting to use the data will need to know the codes that have been used. Using memorable and obvious codes will help overcome this.

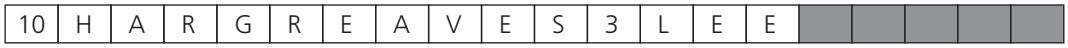
Fixed and variable field lengths

A fixed length field uses the same amount of storage space no matter how much data is present. If a fixed length of 20 characters were used to store surnames then every surname would take up 20 characters of storage space. Names that were shorter than 20 characters would be padded out using spaces. Mr Hargreaves' name would take up 20 characters of storage space and so would Mr Lee's.



Using fixed length fields allows the computer to calculate where one field ends and another begins. This allows direct access to records. This can only be done if the records (and fields) are of fixed length.

If variable length fields are used, then shorter names need less storage space. However, the computer still needs to be able to find where one field ends and another begins. One way of dealing with this problem is to begin each field with a number saying how many characters make up the data. The computer can read this number and then read in the correct number of characters for each item of data. The numbers from 0 to 255 can be stored in a single character's worth of storage space. For this reason, the maximum length of data allowed in a single field is often restricted to a maximum of 255 characters.



The diagrams show that, using fixed length fields, the two names would need 40 characters of storage space. Using variable length fields, the two names take up 15 characters worth of storage space (13 for the characters in each name and two to store the number of characters in each name).

File compression

Data files can be compressed to take up less storage space. One way is to change fixed length fields into variable length fields. A special compression program can be used to compress a file. A compressed file cannot be used until it has been expanded back to its original format. If files are compressed before being sent to another person, then they will need to have the appropriate software to expand the file before they can use the data.

A compressed file takes up much less storage space than the uncompressed version. Compression is often used for archive files and sometimes for back-up files. It is also used when large files need to be stored on a floppy disk.

Key points

- Data is stored in databases which are made up of groups of related files.
- A file is made up of similar records and each record is made up of a number of fields.
- A special field, called a key, is used to identify each record uniquely. The key field is often a made-up value, eg account number, payroll number, etc.
- Key fields can also be used to link files together so that data need only be stored once.
- When a database is set up, the field type for each field will be decided. This identifies the type of data that will be stored in the field and the database software will report an error if the user tries to enter a different type of data.
- Data is often coded to reduce the amount of storage space needed and to speed up data entry and searches.
- Data can be stored in fixed or variable length fields. If direct access is to be used then the fields and records must be of a fixed length.
- Software can be used to compress large files so that they take up less storage space. Compressed files must be uncompressed before they can be used.

Questions

1 Explain the meaning of the terms database, file, record and field.

2 The school keeps a database of student information. One file in this database is the student file where each record is about one student. Give four fields that you would expect to find in a student record.

3 Data stored in a field is often coded. Give the codes that might be used for each of the following items of data:

   a Student's sex.

   b Student's form tutor.

   c The previous school attended by the student.

4 Give three advantages of coding data.

5 Give two disadvantages of coding data.

6 Draw out a table with three headings – field type, explanation and example. In the field type column, write down five different types of field that might be found in a database. Then write an explanation of what sort of data each field type would store. Finally, copy each of the following examples into the correct line of the example column:

- DateOfBirth – Date of birth field in a student record.
- Address1 – The first line of a customer's address in a customer record.
- Paid – A field to indicate whether or not a customer has paid their bill in a customer record.
- StockLevel – A field to store how many items of stock are left.
- CustomerNumber – A field used to identify a customer. Each customer must have a different number.

7 a When databases are designed, files will often be linked together using key fields. Describe two advantages in doing this.

b A video library stores details about members, videos and loans. Each member may borrow only one video at a time. The database designer has identified three files that will be needed. They are member file, loans file and video file. Draw a diagram showing the fields that will be needed in each of these files and how the files will be linked together. Use the key fields MembershipNumber, LoanNumber and VideoNumber.

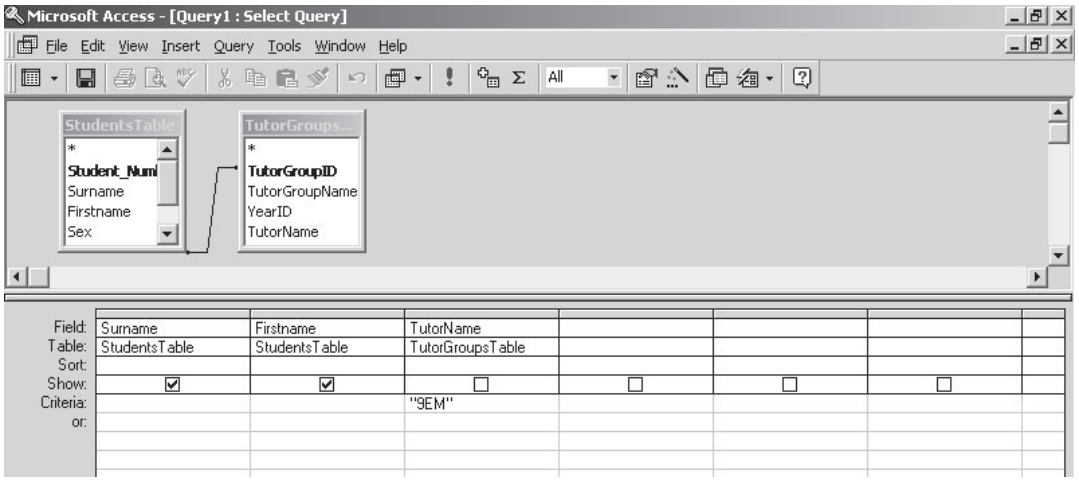
7 Searching and validation

Searching for data

A database can store a large amount of data. One of the most common forms of processing that will be carried out on the data stored in a database is to find data that matches certain conditions. Examples might be to find all customers who have bills that are more than three months overdue or to find all stock items that are running low.

There are two approaches that are used to select records. The first is called query by example. A query by example selection shows the field names in a grid. The diagram below shows a query by example that selects students who are in tutor group 9EM. An example of the data required, in this case tutor group 9EM, is placed in the appropriate column of the grid. Once the selection has been made, the view can be switched to see the data that matches the query.

Only the fields that are shown on the grid will be output. The example shown will produce a list of student surnames and forenames for all the students in tutor group 9EM:



Query by example

Another approach is to use a special database language to create an instruction that the database software can interpret. The following instruction is an example of how you might use such a language to produce a list of all the students in tutor group 9EM:

LIST Surname, FirstName FOR TutorName EQUALS "9EM"

In this instruction, the special words LIST, FOR and EQUALS have been used. LIST is used to identify which fields are to be printed. It is followed by the field names *Surname* and *FirstName* because we want the surname and first name data to be printed. The word FOR is used to identify the field that will have the selection criterion attached to it and the EQUALS gives the type of match that is to be used.

Let's consider a different example. Suppose we want a printout from a supermarket stock file of bar code number, description and stock level for all items supplied by Heinz. The instruction could look like this:

LIST BarCode, Description, StockLevel FOR Supplier EQUALS "Heinz"

Often one condition is not enough. We can use AND and OR to join conditions together. AND will show only records for which both conditions are true. OR will show records for which either or both conditions are true.

The following instruction will print out the description field for all records where the item has been supplied by Heinz **and** the stock level is less than the minimum required. It should produce a list of Heinz products that need to be reordered:

LIST Description FOR Supplier EQUALS "Heinz" AND StockLevel LESS THAN MinimumLevel

Validation

If the data stored in a database is incorrect then the output produced by processing that data will also be incorrect. It is very important to try to ensure that only correct data is stored and processed. Although it is not possible to make sure that data is correct, we can check to see that it is sensible or possible. Data that has an impossible value is obviously wrong. Unfortunately, data that is possible and sensible could still be incorrect. However, if we try to spot the data that is obviously wrong, we will at least be preventing some incorrect data from being processed.

Checking data to make sure that its value is possible and reasonable is called data validation. Validation can take place when data is entered, when it is processed and when it is being output. There are a number of different methods that can be used to validate data:

- **List check** – This method checks the data to see if it is one of a set of possible values that are contained in a list. Examples are validating sex (eg M, F) or validating exam grade (eg A, B, C, D, E, F). A list check can be used when the data entered has to be one of a limited number of known values.
- **Range check** – This is used to check numeric data that should lie between two known values. An example is a student's percentage score in a test. The lower limit of the range is 0% and the upper limit is 100%. The data would be tested to ensure that it was in the range 0 to 100.
- **Presence check** – Some data is so important that a record could not be processed without it. An example of this is a key field. In this case, we can check to make sure that data has been entered in the field. A record with no data in the field would be invalid.
- **Parity check** – Data is transmitted as a series of 1s and 0s. These are normally sent in groups of eight, but only seven of the 1s and 0s are needed to represent a character code. The eighth one is often used to make the total number of ones in the group an even number. Thus, when the data is received, if there is an odd number of ones in the group, there must have been a transmission error. This type of validation is called a parity check. It will detect a single one or zero being misread or mistransmitted.
- **Check digit** – Groups of numbers are often used as key fields to provide unique identifiers. Examples include account number, bar code number and ISBN (International Standard Book Number). Two common errors that occur when long groups of numbers are written or entered into a computer are:
  - Making a mistake copying a single digit.
  - Switching two digits in the number round, eg 1458 instead of 1548.

Either one of these errors can be spotted by using a check digit. The check digit is based on the other digits in the number and on their position in the number. It is calculated and placed at the end of the number. When data is entered, the computer checks that the check digit matches the rest of the number that has been entered. To calculate a check digit:

1 Number the positions of the digits in the number, starting with 2 from right to left.

2 Multiply each digit by its position.

3 Add the results together.

4 Divide the answer by 11 to find the remainder.

5 The check digit is what you must add to the remainder to make 11. If you need to add 10 then the check digit is X. If the remainder is 0 then the check digit is 0.

The following is an example of a check digit calculation:

Step 1: Number the digits according to position:

5	4	3	2	
3	**1**	**1**	**7**	**?** ← *The check digit will go here*

Step 2: Multiply the digits by their position:

5	4	3	2	
↓	↓	↓	↓	**?**

15 + 4 + 3 + 14

Step 3: Add the numbers from the multiplication together:

5	4	3	2	
↓	↓	↓	↓	**?**

15 + 4 + 3 + 14 = 36

Step 4: Divide the answer by 11 to find the remainder:

5	4	3	2	
↓	↓	↓	↓	**?**

15 + 4 + 3 + 14 = 36

$\frac{36}{11}$ = 3 remainder 3

Step 5: The check digit is what you must add to the remainder to make 11. The check digit in this case is 8 since you must add 8 to 3 in order to make 11. Hence, the number with its check digit is:

3 1 1 7 8

Key points

- A database can be searched using a special query language or a query by example screen to select a particular group of records.
- The words AND and OR can be used to link conditions together.
- If AND is used, all the conditions must be true to select the record.
- If OR is used, any one or more of the conditions must be true to select the record.
- Validation is the process of checking data to make sure that it is reasonable and possible.
- A number of different types of validation techniques are possible depending on the nature and type of the data that is being checked.
- A check digit is an important validation check that is especially used for key field values like account number or payroll number. It will always spot a single digit being misentered or two digits being accidentally swapped round.

Questions

1 A stock file contains records about items sold by a supermarket. Some of the fields used are:
- BarCodeNumber
- Description (a description of the item, eg small tin of baked beans).
- Price (how much this item costs).
- QuantityInStock (how many of this item there are left).
- MinimumQuantity (the smallest number there should be before the item is reordered).
- ReOrderQuantity (the number of this item that is ordered)

The instruction:

LIST Description, Price FOR QuantityInStock GREATER THAN 100

would result in a printout listing the description and price of all items that the supermarket had more than 100 of. What instructions would produce lists giving the:

a description and number in stock of all items which cost more than £10?

b description and price of all items with the description 'baked beans'?

c description and number in stock for the item with 5 013413 604531 as its bar code number?

d description and reorder quantity for items with the description 'large cake' that cost more than £5?

e description, quantity in stock and reorder quantity for items which need reordering?

2 Which of the fields in the stock file is the primary key?

3 What is the purpose of a validation check?

4 Write down suitable validation checks for the following data:

a Date of birth for Year 10 student.

b Student's percentage mark for an examination.

c Student's attainment grade on report.

5 Describe in your own words what is meant by the following terms:
   a Validation.
   b Range check.
   c List check.

6 What validation checks would be most appropriate in each of the following cases? Note that it is possible for more than one validation check to be performed on a particular data item:
   a Customer account number (key field).
   b Student test result (percentage mark).
   c Number of items in stock.
   d Price of item.
   e Sex of student.

7 Find a check digit for:
   a 3044.
   b 1292.

8 A number with a check digit can be validated by recalculating the check digit and seeing if it agrees with the check digit that is actually present. Start by writing the number down without the check digit and then perform the same calculation as in Question 7. Compare your answer to the check digit to see if the number was valid. Use this method to find if each of the following numbers is valid. Show all your working:
   a 3117–8.
   b 1044–X.

8 Data capture forms

Collecting data

There are three approaches to collecting data for processing by a computer system:

- **Collect the data on a form** – The data can later be copied directly into the computer or, in large-scale operations, copied onto magnetic tape or disk which is then used to input the data.
- **Use automatic data capture methods** – These involve having the data in a computer-readable format. An example of this is the bar code on an item in a shop.
- **Use direct data entry** – Enter the data into the computer as it is collected. An example of this would be a booking system where the booking clerk would key in the data as it was provided by the customer.

Data capture forms

A data capture form collects data that is usually filled in by hand. The form must be designed carefully so that it collects all the necessary data accurately. The performance criteria for a data capture form are that it must:

- collect all the data that is needed
- guide the user so that they can complete it accurately
- be easy to transfer the data to a computer with the smallest possible chance of error
- have an uncluttered layout
- be a reasonable size (A4 or A5) so that it can be handled conveniently
- be easy to fill in
- be understandable.

Data preparation

Once the data has been collected, it will be copied to a computer-readable format – usually disk or tape. This is called data preparation. In large-scale data handling systems, data preparation is done on equipment that is not connected to the computer, ie off-line data preparation. It is done this way to save using expensive computer-processing time on a task that does not need it.

Design of a data capture form

A data capture form will be designed to satisfy the performance criteria. There are a number of design techniques available to help the designer. For example:

- **Fonts and font size** – Different fonts can be used to help the user find his or her way round the form, eg one font could be used for headings and another for instructions. Different font sizes can act as cues to help the reader understand the function of each part of the form. One size font could be used for instructions and another for examples showing the reader what type of data is expected. Both fonts and font sizes should be used consistently throughout the form.

- **Layout of the form** – It is often necessary to collect several different groups of data. An order form, for example, will need to collect personal data about the customer and data about their order. The form should be set out so that all the related data is collected on the same part of the form. Boxes and lines can be used to group data.
- **Prompts and examples** – The form can include prompts which tell the customer what to fill in. For example, DOB (enter your date of birth). Examples can be given, particularly if the user may be confused as to exactly what data is needed. For example, make of car (eg Ford, Toyota, BMW, etc).
- **Entry boxes** – You can help the user enter data in the required format by using a box that indicates how many characters are needed. This is particularly useful if there is a maximum number of characters allowed, as will be the case if the data is to be stored in fixed length records.
- **Colour and shading** – These can indicate different areas of the form. For example, if there is a section that is to be completed when the form is returned (eg for office use only) this could be shaded in a light grey to indicate to the user that they should not be completing anything in this section.
- **Tick boxes and lists** – These can be used to make it simpler for the user to enter data when there is a limited number of possible options. An example of this might be where you need to collect the user's title (Mr, Mrs, etc).

Questionnaires

A questionnaire is usually used to gather data from a large number of people. This will normally be data about their likes and dislikes, lifestyles or opinions. Questionnaires are widely used in market research and for opinion polls.

The person supplying the data will probably have been stopped in the street or picked at random. In any case, they will not want to spend long completing the questionnaire and so the form must be designed so that it can be filled in quickly.

If you have to design a questionnaire then you must be very careful how you phrase your questions. This is especially important if you are asking for a tick box response or a one-word answer. Questions need to be unambiguous and clear. Also, if you are trying to collect opinions then they should be framed in a neutral way so that they do not influence the answer given.

Key points

- A data capture form is designed to collect data for input to a computer system.
- The data on the form must be copied to a computer readable format.
- Copying the data may introduce errors into the data.
- The form must be carefully designed to reduce the chance of errors both when it is completed and when it is copied.
- The form must be designed to collect all the data that is needed.

Questions

1 Data capture forms and questionnaires are both used to collect data for input to computer systems.

a What is the difference between them?

b How will this difference influence the design of the two types of form?

2 A new video library has opened up. It needs an application form for members to complete. When the membership form is received, the member will be given a membership number that will consist of five characters. The data will be entered into a computer but the form will be filed in a card index system that takes postcard-sized documents. The main reason for keeping the card is that it will prove that the member has accepted the library's terms and conditions. The forms will be stored in order of membership number. Design an application form for the video library showing as much detail as possible.

3 A local clothes store is considering extending its opening times either by staying open on two evenings a week or by opening on Sundays from 10 am until 4 pm.

The manager is particularly keen to generate more custom from the 14 to 18 age group. She needs to know how many people in this age group would take advantage of increased opening. She also needs to know which option customers would prefer and how late they would want the shop to stay open for if the weekday evenings option was adopted.

Design a data capture form that would allow customers to be surveyed to provide the data that would allow the manager to obtain the information she needs.

Glossary

Application	A computer program written to perform some task for the user.
Backing store	Where data is stored when not actually being processed by the computer.
Bespoke software	Application software written to order for a particular user.
BIOS	Basic Input/Output System. The program that starts up (boots) the computer system.
Bootstrap loader	A small computer program that loads the operating system program into the computer's memory when it is first switched on.
Byte	Unit used to measure storage capacity. Equivalent to one character being stored.
CD-ROM	Compact disc read only memory. Optical storage that is read only.
CD-R	Compact disc recordable. Optical storage that can be written to once.
CD-RW	Compact disc rewritable. Optical storage that can be rewritten.
Check digit	An extra digit placed at the end of a number to perform self-validation. A check digit cannot be used on numbers where calculation will be performed but it is extensively used for key field identification numbers.
Computer system	Combination of hardware and software designed to process data.
Data	Raw values input to and stored in a computer system.
Data capture form	A document used to collect data for input to a computer system.
Data compression	A method of storing data so that it takes up less space.
Data preparation	The process of copying data from a data capture form to a computer readable format such as tape or disk.
Digital camera	Used to capture still or moving digital images that can be input and processed directly by a computer.
Digitising	The process of converting a sound, picture or drawing to a series of numbers that can be stored and processed by a computer system.
Direct access	The data is read or written without the need to access any other data.
Direct access file	A form of file access where a particular record can be processed without the need to process or access any other records in the file by calculating its position and going directly to the required record.

Dot-matrix printer	Impact printer that prints by firing pins at an inked ribbon to make dots on the page.
DVD-ROM	Digital versatile disc read only memory. Large capacity optical storage that is read only.
DVD-RAM	Digital versatile disc random access memory. Large capacity optical storage that is rewritable and held within a special protective cartridge.
Field	Stores one piece of data such as the colour of a stock item or customer surname in a database.
File	Computers store data on disk in files. When talking about a database, a file is where data about one type of thing (stock item, customer, etc) is stored. It is made up of records.
File format	A way of structuring data so that it can be read by one or (usually) more applications. All data must be stored in a file format that can be read by at least the application that stored it.
Flash memory	A type of memory chip that can be written to and that retains its data when the power is turned off. Slower to access than RAM.
Floppy disk	Small magnetic disk which can store about 1.44 MB of data.
Footprint	The amount of desktop space that a device takes up.
Generic software	Software written to do a wide variety of jobs.
Graphics digitiser	An input device that consists of a tablet and stylus and that is used for inputting drawings.
Hard disk	Rigid, fast spinning disk with fast access and a large capacity.
Hardware	The physical components of a computer system, eg printer, VDU, keyboard, etc.
Information	Processed data that is output from a computer system.
Ink-jet printer	Non-impact printer that prints by firing droplets of ink at the paper.
Input device	Something that is used to enter data into a computer system.
Key field	A field that uniquely identifies a record.
Joystick	Device used to input direction. Mainly used in games applications.
Laser printer	Non-impact printer that prints by fusing small particles of toner onto the paper.
Light-emitting diode (LED)	A small device that converts electrical energy directly to red, green or orange light.

Light pen	Input device for graphical data.
List check	Validating data by checking to see that it is one of an allowed set of values contained in a list.
Magnetic tape	Sequential storage medium, sometimes used for active files but more commonly used for back-up.
Medium	The material, such as magnetic tape or paper, on which data is stored or information output.
Memory	Where data is stored while it is being processed.
Model	Computer software that predicts how a real-world situation or object will behave under different conditions.
Mouse	Hand-held input device used to input position and speed. Often used to point to or select items in a graphical user interface.
Multi-tasking system	A computer system where several programs are loaded into central memory at the same time.
Multi-user system	A computer system where several users appear to have access to the computer at the same time. Point of sale terminals in a supermarket are part of a multi-user system.
Off-line	Not connected to the computer.
On-line	Connected to the computer.
Operating system	A computer program that is present in memory all the time that the computer is working. It controls and manages the computer system resources.
Optical character recognition (OCR)	A system of scanning written characters so that they are recognised for input to a computer.
Parity check	Method of self-validation where the number of 1s making up a group of eight bits is made even by using the parity bit.
Plotter	A device that produces hard copy output by drawing on the paper using a series of pens.
Presence check	Checking that an essential field contains data.
Processing	Performing actions on data (such as calculating, searching or sorting) to provide information.
QWERTY keyboard	Keyboard with the letter keys arranged in the same way as on a standard typewriter.

Query	An instruction to a database program to select certain records according to the criteria defined either by words or by a screen representation.
RAM	Random access memory – stores the user's data and software. Loses its data when power is turned off.
Range check	Method of validation that checks a data value which lies between two known extreme values.
Record	Stores data about one occurrence of the thing that the file holds data on (one stock item, one customer, etc). It is made up of fields.
Resolution	The number of dots per inch that a printer or VDU can produce. A measure of the quality of the output that the device can be expected to produce.
ROM	Read only memory – data is permanently stored in this memory chip when manufactured and cannot be changed.
Scanner	Input device used to digitise pictures or as part of an optical character recognition system.
Sequential access	Data is read or written in order.
Simulation	Computer software that behaves like a real-life system or object.
Software	Computer programs that are made up of a series of instructions that the computer follows to perform some task.
Source document	The original document on which data was captured.
System flow chart	A diagram that uses special symbols to represent the flow of data through a computer system.
Tape cartridge	Self-contained tape as opposed to reel-to-reel tape.
Touch pad	Flat surface which detects movement of a finger touching it. Used as a pointing device on laptop computers.
Touch screen	Input device where the user selects an item from the computer screen by pointing to it.
Tracker ball	Specialised pointing device where a ball is rotated by hand to provide an accurate input of small movements.
Validation	Checking data values to make sure that they are reasonable and possible values. Validation is performed in order to try and detect incorrect data.

Virtual reality	Computer system that uses visual and sound input to produce the effect that the user is actually present in a computer-generated environment.
Visual display unit (VDU)	Output device – the monitor attached to a computer.
Volatile storage	Storage where the data is lost when the power is turned off.